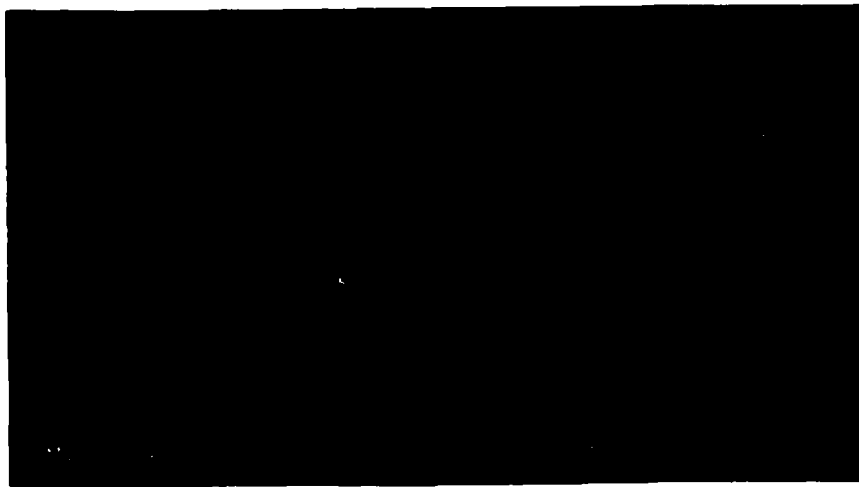②

ARC Professional Services Group

Defense Systems Division

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TEST REPORT

FOR

PHOTONIC SENSORS USED IN ELECTRIC FIELD MEASUREMENT OF SIMULATED ELECTROMAGNETIC PULSES

JANUARY 1991

Prepared Under Contract N00014-90-C-2033

For

The Naval Research Laboratory
Fiber Optics Technology Programs (Code 6503)

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Prepared By: *Roland D Blackson, Jr.*
Program Director
ARC Professional Services Group

Approved By: *[signature]*
Technical Director
ARC Professional Services Group

Approved By: *[signature]*
Operations Center Director
ARC Professional Services Group

Prepared by

ARC Professional Services Group   1375 Piccard Drive, Rockville, MD 20850

EXECUTIVE SUMMARY

This report documents the results of field tests conducted on three photonic sensors which were subjected to a simulated threat-level Electromagnetic Pulse (EMP) environment at the EMP Simulation Facility located on the Naval Air Test Center (NATC), Patuxent River, Maryland.

The field tests were a part of an ongoing Research and Development (R&D) effort initiated in 1986 for the Fleet Aircraft Assessment for Navy Testing and Analysis for EMP Limitation (FAANTAEL) project, under the sponsorship of the Naval Air Systems Command, Electromagnetics Environmental Effects Branch (AIR-5161). The R&D plan includes the investigation and testing of promising candidate EMP sensors which would result in the engineering development and testing of a prototype aircraft fiber optic sensor system for use in Electromagnetic Pulse (EMP) assessments.

The tests reported in this document were held during the summer of 1990 at the NATC EMP Simulation Facility as an adjunct to other electromagnetics testing being conducted for the U.S. Army Harry Diamond Laboratories (HDL). The test environment presented during the series was ideal for sensor test requirements since adequate data acquisition resources were available and no aircraft were on the pad to perturb the electromagnetic fields generated by the EMP Simulator Facility pulser.

During the course of the FY90 research and development effort, an update of a previous sensor survey was conducted and candidate sensors for field testing identified. Two government photonic sensors, from the National Institute of Standards and Technology (NIST) and the Naval Research Laboratory (NRL) respectively, were identified as most promising for the FY90 tests. The NIST photonic sensor, under the sponsorship of HDL, was a modified and upgraded version of a sensor previously tested during FY89 tests. The NRL photonic sensor was identified as a candidate for test during the FY90 research and development work. In addition to the NIST and NRL photonic sensors, a prototype fiber optic sensor from the MetriCor corporation, developed for measurements of Hazards to Electromagnetic Radiation to Ordnance (HERO), was included in the tests to ascertain the sensor response to high intensity electric fields. Several other candidate sensors were identified for possible testing but timely arrangements could not be successfully made for their inclusion.
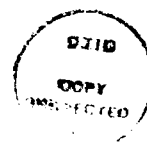
Preliminary work performed in preparation for the field test included the development of test planning documentation, development of a field map, procurement of equipment and arrangements and liaison with NATC for test conduct, data acquisition, and data processing.

A total of 45 valid pulser shots were recorded and analyzed. The data results clearly show that the outputs of the NIST and NRL photonic sensors approximated the simulator pulse characteristics (amplitude, frequency, and waveform) when compared to a conventional (non-photonic) reference sensor used in a side-by-side test configuration. The NIST photonic sensor output most closely approximated the reference sensor data in field strength and was linear across the measurement space. The NRL photonic sensor output approximated the linearity of the reference sensor but was, on the average, 3.8 kV/m lower in field strength. The MetriCor fiber optic sensor was unable to record pulser parameters, as expected, but successfully operated throughout the test in field strengths to 50 kV/m.

The primary conclusions reached as a result of the test are that the outputs of both the NIST and NRL photonic sensors replicated the overall performance of the reference sensor and that both are suitable candidates for further prototype EMP sensor system engineering development.

It is also concluded that the MetriCor fiber optic sensor is capable of operating satisfactory in an electromagnetic electric field intensity up to 50 kV/m.

Recommendations based on the test results include: (1) proceed with the ongoing R&D plan by initiating the engineering development and testing of a prototype sensor system in the FY91 program; (2) continue to plan and conduct tests of recently identified candidate field sensors and others that were not included in the FY90 test series; and (3) continue to monitor the development of photonic sensors that might be candidates for use as EMP sensors.

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1.0 INTRODUCTION

1.1 Purpose

This report documents the results of tests to record and analyze the characteristic response of three photonic Electric-field (E-field) sensors to simulated Electromagnetic Pulse (EMP), compared to that of a reference metallic sensor. Work was performed under Naval Research Laboratory (NRL) contract N00014-89-C-2033, sponsored by Naval Air Systems Command (NAVAIR).

1.2 Scope

Tasks included: (1) selection of candidate sensors capable of measuring the E-field content (intensity and frequency spectrum) of simulated EMP phenomena generated by the Horizontally Polarized Dipole (HPD) EMP simulator at the Naval Air Test Center (NATC), Patuxent River, MD; (2) liaison with sensor designers, NATC personnel, and others as necessary to delineate test requirements and constraints; (3) development of a sensor test plan; (4) sensor tests in the HPD EMP simulation; (5) analysis of the test data; and (6) generation of the Test Report. The activities discussed herein were performed during the period March 1990 - January 1991.

1.3   Background

Since 1985, the Naval Research Laboratory (NRL) and ARC Professional Services Group Defense Systems Division (ARC) have conducted an R&D effort to produce a prototype fiber optic sensor system for application to EMP field measurement. The work was sponsored under the Fleet Aircraft Assessment for Navy Testing and Analysis for EMP Limitation (FAANTAEL) project managed by NAVAIR Electromagnetic Environmental Effects (E^3) Branch, AIR-5161.

Under NRL contract N00014-83-C-2153, ARC (then ORI, Inc.) reported the feasibility of using optical materials, particularly fiber optics, to sense electric (E) fields and magnetic (H) fields that might be produced by EMP phenomena. Efforts during the contract produced laboratory proof-of-principle models which could be further developed and tested under simulated EMP conditions. These sensors would not be susceptible to induced electromagnetic fields and would be small and lightweight for an on-aircraft installation. The results of these investigations were reported in ORI, Inc. Technical Report No. 2582, May 1986 entitled "An Evaluation of FOSS Technology For Use In EMP Instrumentation." The technical report recommended a plan of action similar to a plan suggested by Samyal and Naumann under Defense Nuclear Agency (DNA) sponsorship.

The NRL sponsored R&D plan called for literature searches and an industry survey for candidate sensors. The survey accomplished during 1987-88 resulted in the identification of candidate National Institute of Standards and Technology (NIST) photonic E-field sensors. Dr. Keith Masterson, NIST, developed two photonic E-field meters, PEFM-2 and PEFM-15, for Sandia Laboratory and the U.S. Army Aviation Systems Command, respectively. Both sensors were developed for continuous wave metrology applications. Although EMP-strength field measurements were not considered as design criteria, these applications were considered feasible. In July 1989, ARC, under contract to NRL, field tested these two photonic E-field sensors at the HPD EMP simulator facility to characterize sensor performance in relation to representative EMP threat parameters. These tests were reported in ARC Technical Report 2908 under NRL Contract N00014-86-C-2427. Results and lessons learned from those tests were provided to NIST. Continued development led to an upgraded sensor, PEFM-15C, under the sponsorship of the U.S. Army's Harry Diamond Laboratories. Tests of that upgraded sensor are documented in this report.

Following the FY89 testing of the NIST photonic sensor at NATC, the sensor survey was updated. A photonic E-field sensor under development at NRL, which had been installed in a test aircraft for flight demonstrations for another application, was identified as an EMP sensor candidate for testing in FY90.

In the Spring of 1990, ARC conducted discussions with NANOFAST and MetriCor, commercial companies involved in optical sensors and transmission systems. Discussions with NANOFAST for a test sensor proved unsuccessful. MetriCor offered one of their developmental Hazards of Electromagnetic Radiation to Ordnance (HERO) sensors to ascertain survivability characteristics. The MetriCor sensor's principle of operation precluded response to the transient (nanosecond regime) characteristics of the EMP pulse.

2.0 TEST METHODOLOGY

The technical approach for the EMP E-field sensor tests involved identification of test requirements, planning and conducting the test, and analysis of resultant test data (Section 3.0).

2.1 Test Requirements

The test was conducted at the HPD facility at NATC, which is described in Appendix A. All test sensors and the D•Dot reference sensor are described in Appendix B. The test team, in liaison with sensor designers, determined test requirements and constraints and identified and corrected interface problems existing between the sensor systems and test facility equipment; e.g., impedance matches between interface boxes and instrumentation digitizers. The test team also met with HPD site personnel to determine the most advantageous test dates to maximize data collection and to minimize interference with other ongoing tests. Mutual agreement was reached concerning organizational responsibilities, method of testing and data collection, test equipment requirements and source, and general administrative and site safety requirements. The test team also contacted the design engineers of the Maxwell generator that produces the simulated EMP to learn as much as possible about the field, to facilitate determination of locations for the sensors on the test pad and for analysis of the collected data.

2.2 Test Plan Development

In preparation for the test, information about the sensors, test site, and test requirements was collected to aid in preparation of a test plan. Since the EMP field sensors were to be tested in conjunction with Harry Diamond Laboratory tests of Army equipment, NATC did not require a detailed test plan. An abbreviated test plan for the sensor tests, Appendix H, was written, submitted, and approved.

2.3 Test Conduct

Tests of the sensor systems were conducted over a period of three days, 28-30 August 1991. August 27th was utilized for marking test points on the test pad and accepting custody of and setting up NATC equipment needed for the tests. Even though test shots were taken during the first two days, comparative test data for this report were not taken until the third and final day, when data from forty-five useable shots were collected. The EMP waveforms and their fast Fourier transforms generated from these shots appear in Appendix D. Not all sensor systems were available on days one and two; pulser shots on day one were limited to the afternoon due to ongoing test preparation by Harry Diamond Laboratory personnel. Accounts of each day's activities follow.

2.3.1 Test Preparation. On 27 August, test points were marked on the test pad centerline for placement of the sensors during tests. The centerline is drawn perpendicular to a line on the test pad that is a projection of the pulser and its antenna. Test points were placed on the centerline because Maxwell Laboratories engineers indicated that the polarization of the field could be accurately predicted only along the centerline. These points had to be calculated since a field map did not exist. HPD personnel provided field map data, but that data contained only a few points along the centerline. The few centerline points in the HPD-provided data were analyzed and showed that the field varied inversely with the radial distance from the pulser as predicted by the Maxwell engineers. Using this information, the available data was extrapolated and the field map illustrated in Figure 2-1 was plotted. The field map generation is discussed in more detail in Appendix A.

2-1
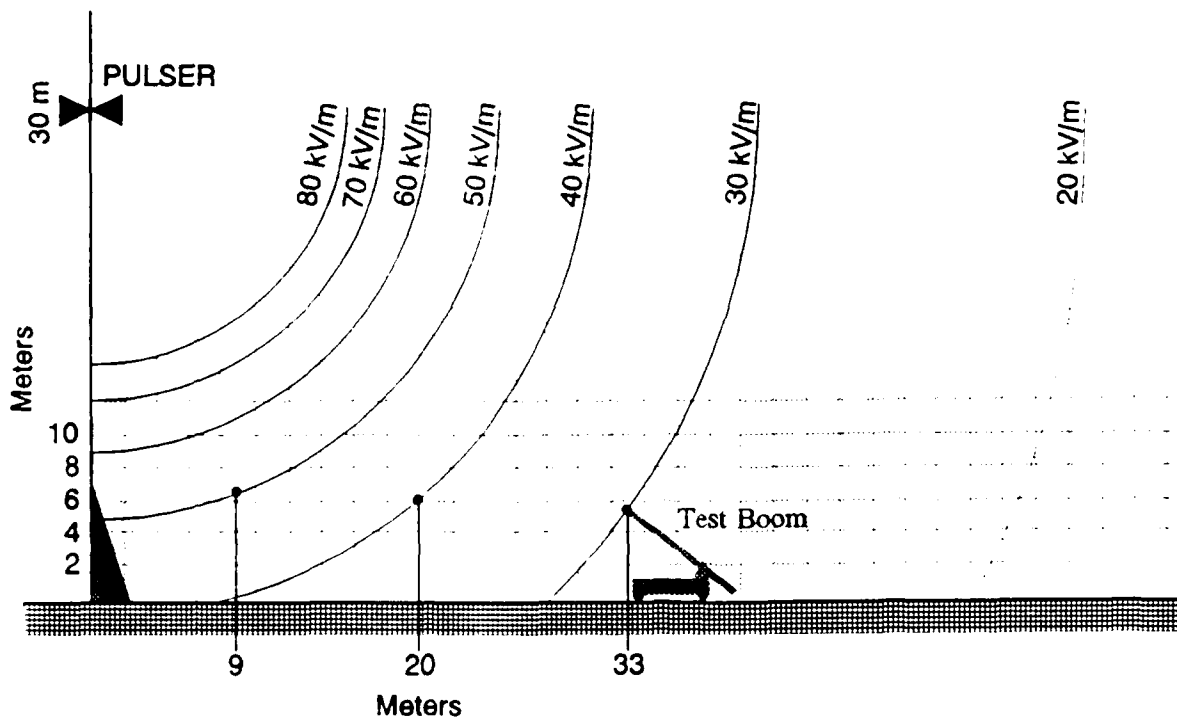
Figure 2-1. HPD Site Field Map

Test point locations derived from the field map were physically marked on the test pad. Distances indicated on the field map are measured from a point on the pad directly beneath the pulser. The initial test location was at the 9 meter (m) position, which exposed the sensors to approximately 50 kilovolts per meter (kV/m). Subsequent locations were at the projected 40 kV/m (20 m) and 30 kV/m (33 m) positions. The dielectric boom for mounting the sensors during tests was placed on the test pad centerline as illustrated in Figure 2-1. A D•Dot reference sensor was collocated on the boom with the test sensors. HPD site personnel provided indoctrination in use of the reference sensor and on site operating procedures and equipment, including CATALYST software and LeCroy 6880 digitizers. Sensor and test information was provided to HPD personnel for entry into the data base to set up the CATALYST software to collect test data. CATALYST provides pulse number, rise time, peak signal, and Fast Fourier Transforms (FFTs) of the sensor outputs.

2.3.2 Preliminary Sensor Test. Figure 2-2 illustrates a simplified test setup, and Appendix C provides a more detailed diagram and discussion. Outputs from all sensors, except the MetriCor sensor, were separately routed as optical signals to the DAPS vans, where they were reconverted to electrical signals, digitized by LeCroy 6880 Digitizers, and collected by the DAPS computers using CATALYST software. The MetriCor sensor output was routed as an optical signal to the DAPS van to its dedicated interface unit and processor.
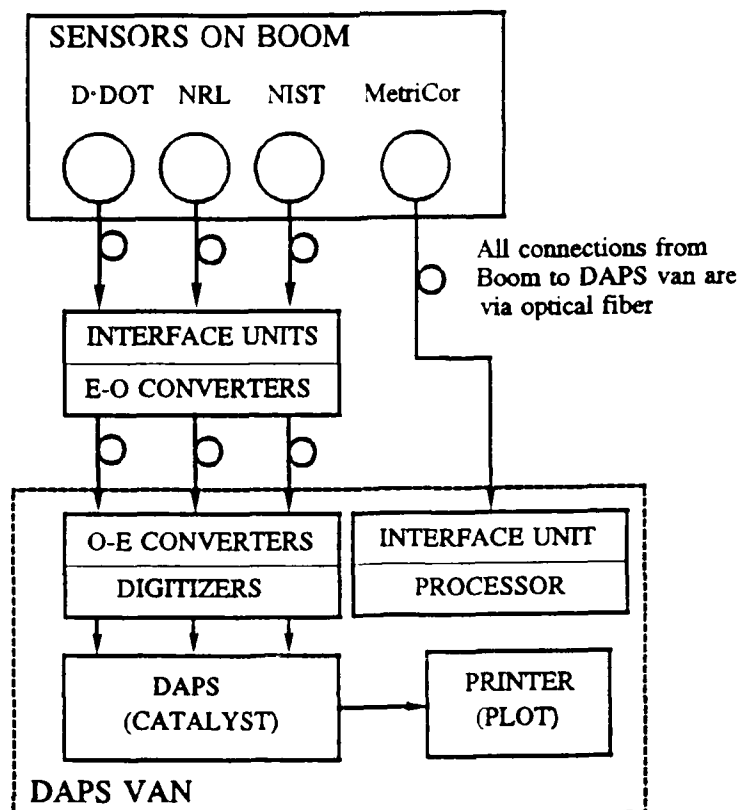
Figure 2-2. Simplified Test Setup

On 28 August, the D•Dot, NRL, and Metricor sensors were mounted on the dielectric boom and connected, as illustrated in Figure 2-2. Test shots on 28 August were used to:

(1)   Familiarize all test personnel with site procedures, sensor to DAPS equipment connections, and DAPS operation;

(2)   Obtain the optimum gain/attenuation settings on the data collection equipment for each sensor;

(3)   Make necessary adjustments on the interface units of the sensors.

As expected, the Metricor sensor system provided no discernible output, but continuity tests were conducted periodically to insure sensor survivability.

On 29 August, the NIST sensor system arrived. When the polarization-maintaining fiber for the sensor would not reach the DAPS van, conventional optical fiber and a laboratory polarization controller were tried unsuccessfully. It was then necessary to place the NIST sensor interface unit on the test pad, thus exposing it to the simulated EMP E-field. The interface was insufficiently shielded for the intense EMP and the data readout indicated significant ringing due to electromagnetic interference (EMI). The interface unit was repositioned to insure that the ringing was due to the E-field and to minimize its effects. It was also determined that the MetriCor sensor had survived in the full EMP environment, thus satisfying the requirements of the tests on that sensor. No further tests were conducted on the MetriCor sensor.

2-3

2.3.3 Data Collection. Lessons learned during the first few days of data collection were used to devise the final test strategy. On 30 August, the D•Dot, NRL, and NIST sensors were placed as shown in the test setup diagram in Figure 2-2. The boom was first positioned at the 9 m position as shown on the field map (Figure 2-1). The boom was elevated to allow the D•Dot sensor to be pointed directly at the pulser for proper calibration. This determined the elevation of all other sensors on the boom.

After several calibration shots for each sensor, the data from five useable shots were recorded for each sensor. The DAPS equipment allowed selection of each sensor output for display of its waveform and data after each shot. Hence, it was quickly determined if collected data from all the sensors were usable for that particular pulse. After documenting five good shots, both the NIST and the NRL sensor probes were rotated to reverse the dipoles of each probe and data from five more shots were recorded. Data taken with reversed dipoles reduced the effects of noise associated with the sensors. The boom was then moved to the 20 and 33 m positions and data from five successful shots were recorded for each sensor in each dipole orientation at each location.

3.0 DATA ANALYSIS AND TEST RESULTS

3.1 Data Analysis

The data presented was compiled by DAPS, NRL, and NIST. The NRL and NIST data displayed in Appendix F constitute calculations of the E-field intensities as measured by their respective sensor systems. Appendix G constitutes an independent calculation of the test sensors's E-field intensities. This independent analysis of the HPD EMP Simulator results from DAPS consists of three parts: consideration of the peak electric field amplitude measured by the sensors; accuracy of the sensors' replication of the simulated EMP waveform; and examination of the frequency content of the responses.

3.1.1. Amplitude Measurement. The HPD Pulser Records are contained in Appendix F. This information displays particulars such as the sensor type, location, antenna configuration, shot number, peak value and rise time as well as the date. An explanation of the data is provided in the appendix. The peak readings in kV/m in Appendix F for both the NRL and NIST sensor systems were derived from calibration data provided by the two respective laboratories.

Two indicators in these data are immediately apparent: (1) peak value readings for both the NRL and NIST sensor systems are consistently lower than those of the D•Dot (reference) sensor, and (2) there appears to be an inconsistency in the peak value readings for the NIST sensor antenna configurations at the 9 m and at the 20 m positions: i.e., the values . These apparent anomalies are addressed by (1) normalizing the data to the output of the reference sensor on the boom, and (2) by averaging the NRL and NIST readings for a given location of the boom.

The normalization process consisted of an examination of the raw data gathered on both the NRL and NIST sensors and the calculation of conversion factors for each of the NRL and NIST sensors. This procedure assumed that the D•Dot sensor measured 50 kV/m, 40 kV/m, and 30 kV/m at the 9 m, 20 m, and 33 m positions, respectively. The normalized calculations are contained in Appendix G. The last page of Appendix G displays the calculations obtained by averaging the NRL and the NIST readings. Sample calculations are provided in Appendix G to illustrate the method used for compiling the tables.

The normalized data from Appendix G was used to develop the conversion curves displayed below in Figures 3-1 and 3-2. Three data points were selected (9 m, 20 m, and 33 m) in order to determine the characteristic curves in both Figures 3-1 and 3-2. As shown, both characteristic curves are linear. The reciprocal of the slope from each of these curves was then used to calculate conversion factors for comparing outputs of the reference sensor with those of the NRL and NIST sensors. The resulting conversion factors for the NRL and NIST sensors are 3.72×10^7/m and 1.62×10^5/m, respectively.

These conversion factors were used to construct the data tabulated on page G-4 of Appendix G. Figure 3-3 is an E-field plot of that data. For the three test positions of the boom, Figure 3-3 shows that the calculated NIST sensor output is approximately 1.5 kV/m higher than that of the reference sensor, and that the NRL sensor output is approximately 3.8 kV/m lower than that of the reference sensor. The standard deviation of the data for both the NRL and NIST sensors in Figure 3-3 is indicated by the vertical height of the individual data points in the figure. The NIST data is close to one standard deviation from that of the reference sensor. Statistically, the NRL data is significantly lower than that of the reference sensor. This constitutes an unknown systematic error in the test series.

By using these methods it was possible to derive calibration factors independently of the NRL and NIST derived calibration factors and to smooth the data due to any internally generated noise or due to the fact that the antenna orientations for the NIST probe may have been recorded in error.
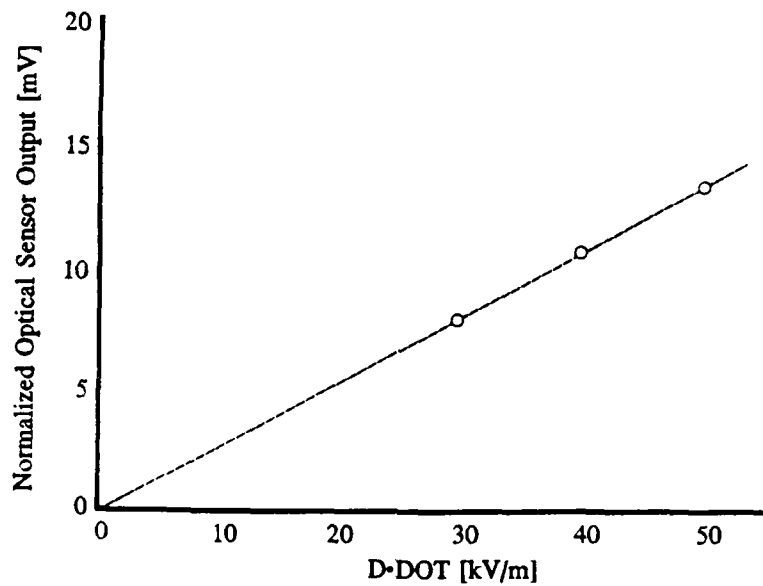

Figure 3-1. Conversion Curve for the NRL Sensor
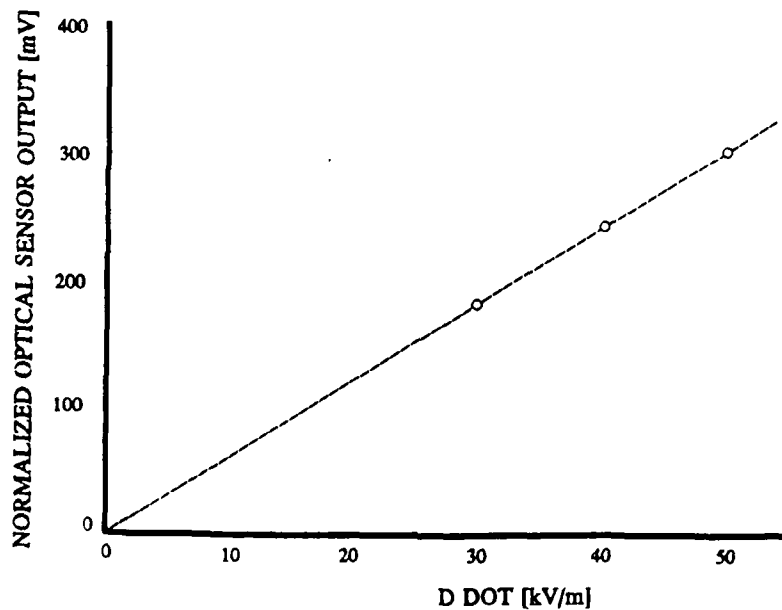
Figure 3-2 Conversion Curve for the NIST Sensor
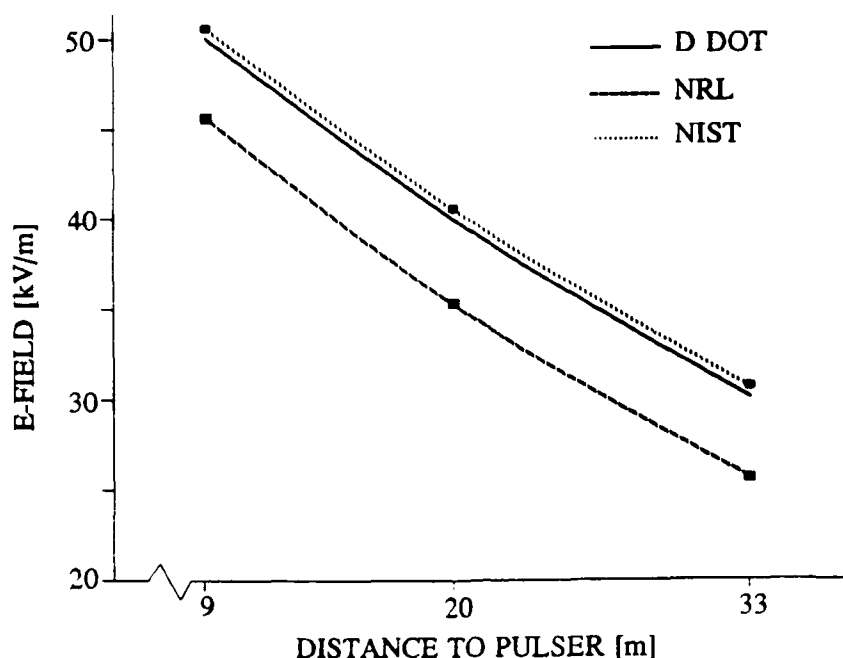
Figure 3-3. E-field Plot for D•dot, NRL, and NIST Sensors
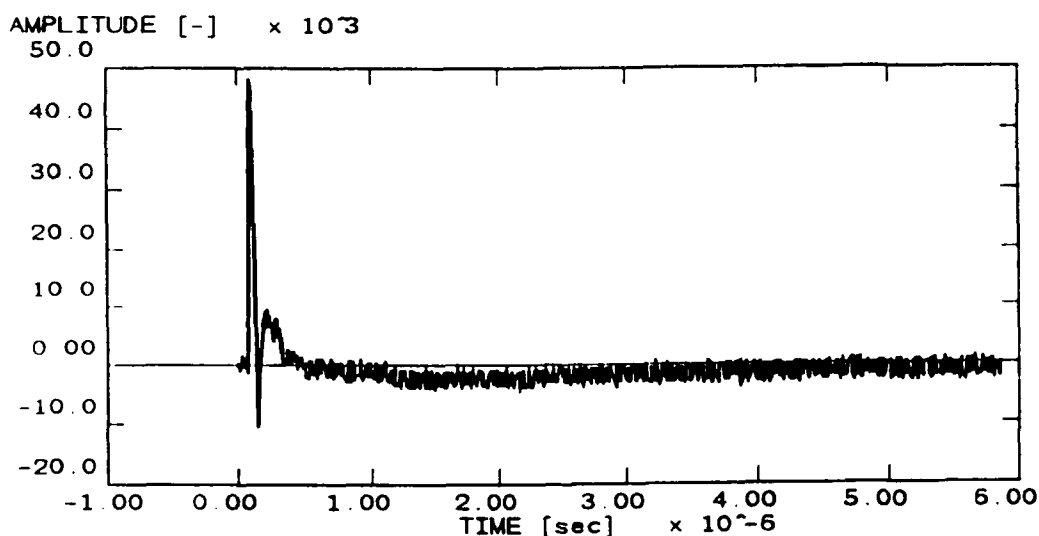
Figure 3-4. Sample CATALYST Plot (Source: NATC)

3.1.2 Pulse Waveform. The conventional data output provided by the CATALYST software does not provide sufficient information for a precise examination of the sensor waveform response characteristics. The output of the CATALYST software shows the amplitude of the measured field for each sensor as a function of the 10,000 data points over a nominal range of 1-8 µsec recorded by the digitizer for each pulse. A sample CATALYST software output is shown in Figure 3-4. Since the duration of the simulated EMP is measured in nanoseconds, a clearer representation of the waveform during the period of interest was produced by software which expanded the time line. Appendix E is a collection of expanded plots, and Figures 3-5a, b, and c illustrate example plots for the D•Dot, NRL, and NIST sensors, respectively. The plots show that the output of both the NRL and NIST sensors are similar to that of the D•Dot sensor.

3-3
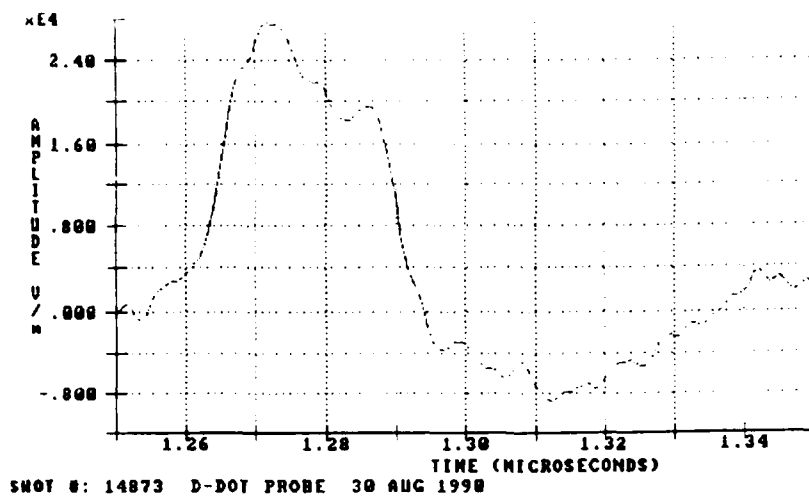
Figure 3-5a. Sample Expanded Time Line Plot of the D•Dot Sensor (Source: ARC)
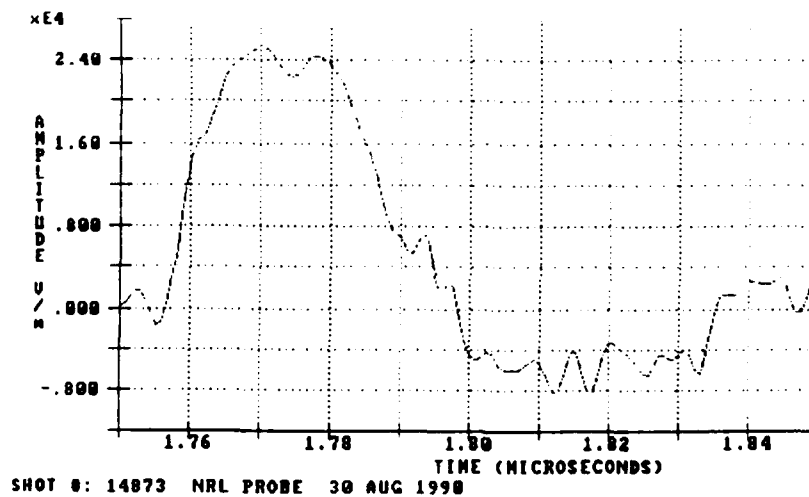
Figure 3-5b. Sample Expanded Time Line Plot of the NRL Sensor (Source: ARC)
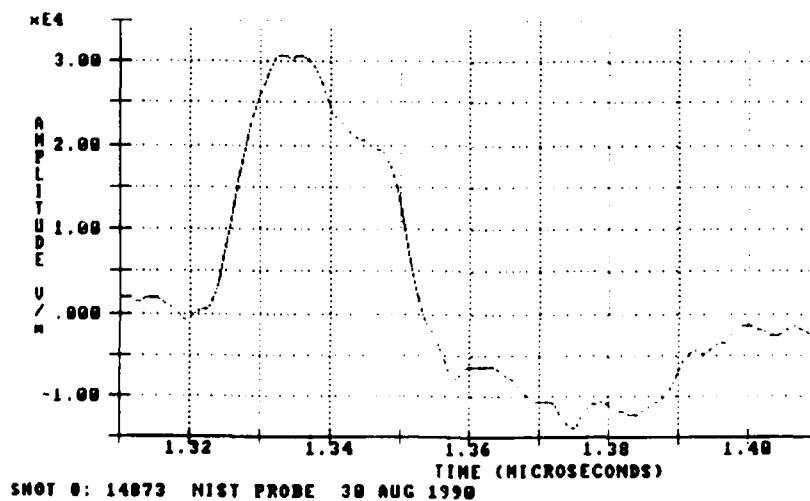
Figure 3-5c. Sample Expanded Time Line Plot of the NIST Sensor (Source: ARC)

3-4

3.1.3 Frequency Content. Another important factor in considering the response of the sensors to EMP, is the frequency content of that energy. An acceptable candidate sensor should be able to faithfully record the frequency content of the EMP. This is found by taking the fast Fourier transform of the amplitude data. Figure 3-6 is the Fourier transform of a theoretical EMP. There is a constant amplitude up to 20 MHz, followed by a rolloff to approximately 3000 MHz where the rolloff increases (the slope becomes greater).

The test sensor graphs are not as clean as the theoretical plot because of noise introduced by the sensor electronics. An examination of the transforms shows that the same basic frequency distribution characteristics exists for the test sensors as for the theoretical plot. The theoretical FFT in Figure 3-6 will show that the slope from 20 MHz to 200 MHz is approximately -22 dB/decade. Figures 3-7a, b, and c are examples of FFT curves for the D•Dot, NRL, and NIST sensors, respectively, for the same HPD shot. Analysis of the D•Dot, NRL and NIST sensor FFTs, shows rolloffs of approximately -25, -19, and -27 dB/decade, respectively.
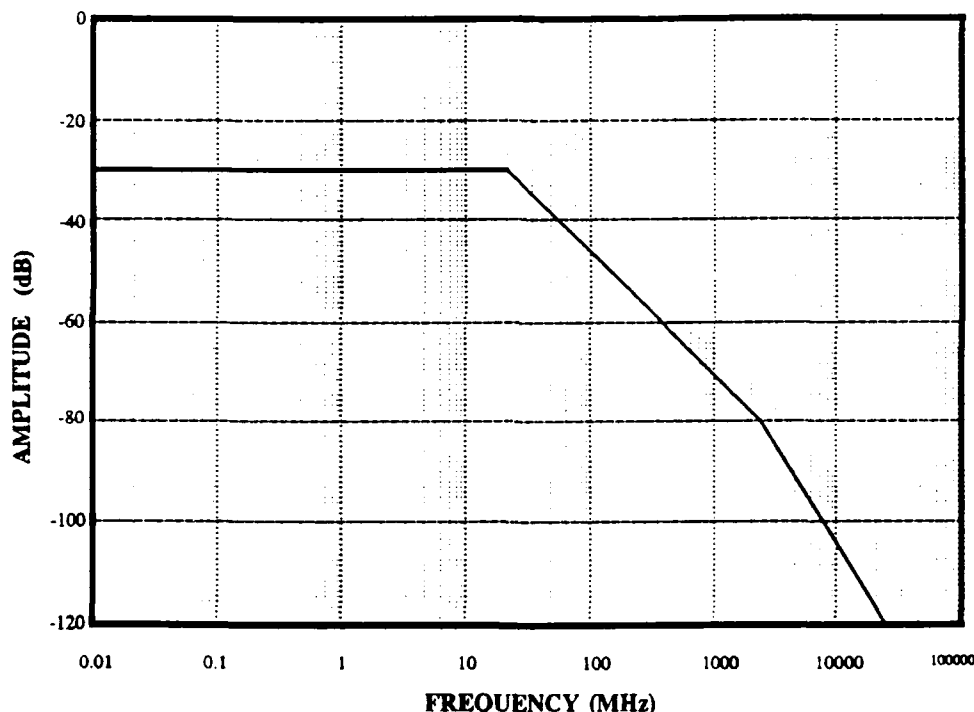
Figure 3-6. Fast Fourier Transform for Theoretical EMP

3-5

MAGNITUDE [/Hz]

Figure 3-7a. Sample D•Dot Sensor FFT Curve (Source: NATC)

MAGNITUDE [V/M/Hz]

Figure 3-7b. Sample NRL Sensor FFT Curve (Source: NATC)

MAGNITUDE [V/M/Hz]

Figure 3-7c. Sample NIST Sensor FFT Curve (Source: NATC)

3.2 Errors

There are two types of statistical errors; random and systematic. This section discusses those types of errors as well as their probable causes or sources.

3.2.1 Random Errors. In general, for large data population samples, the collective impact of random errors results in a Gaussian distribution of errors whic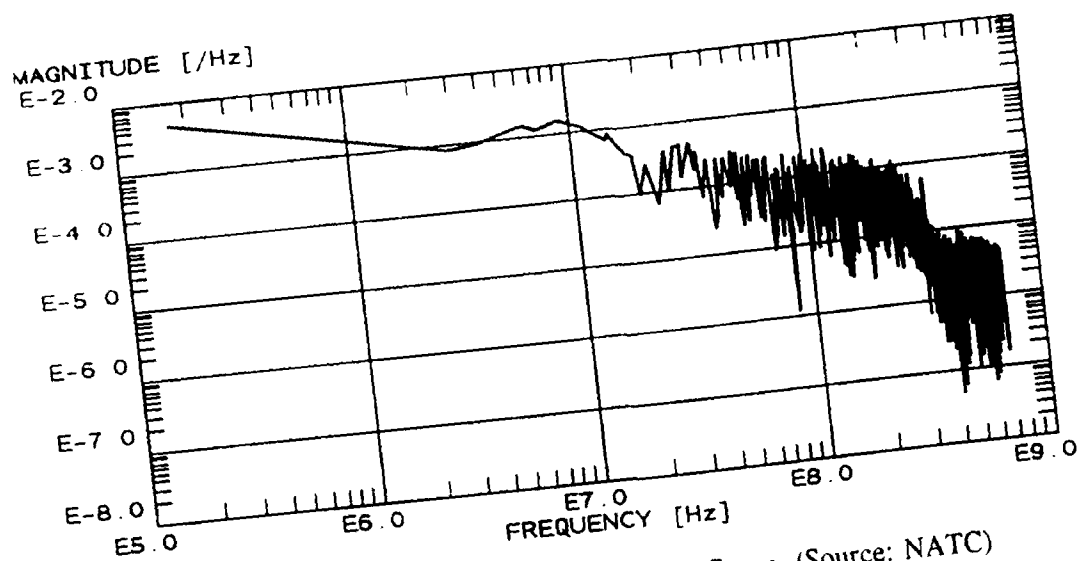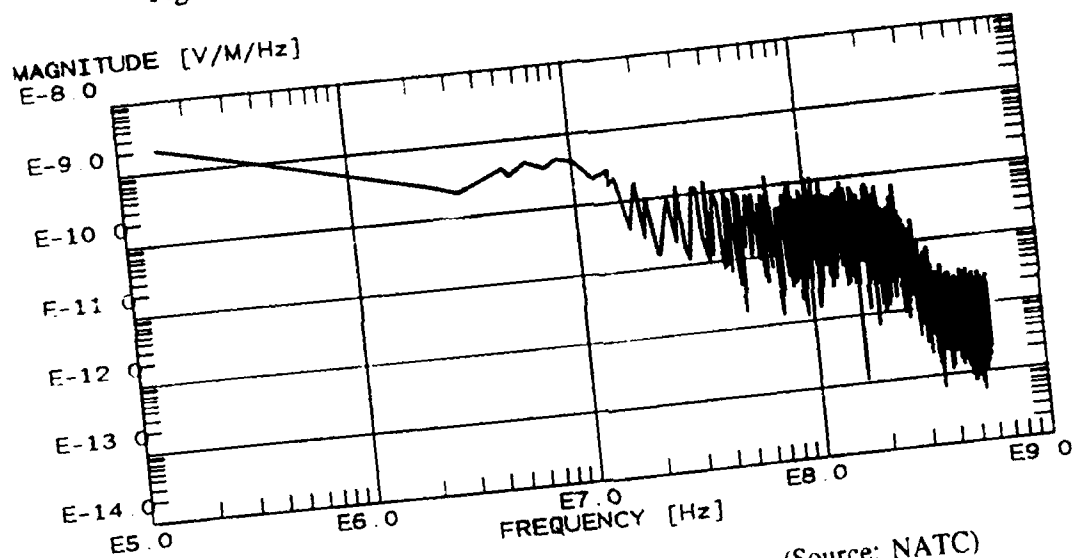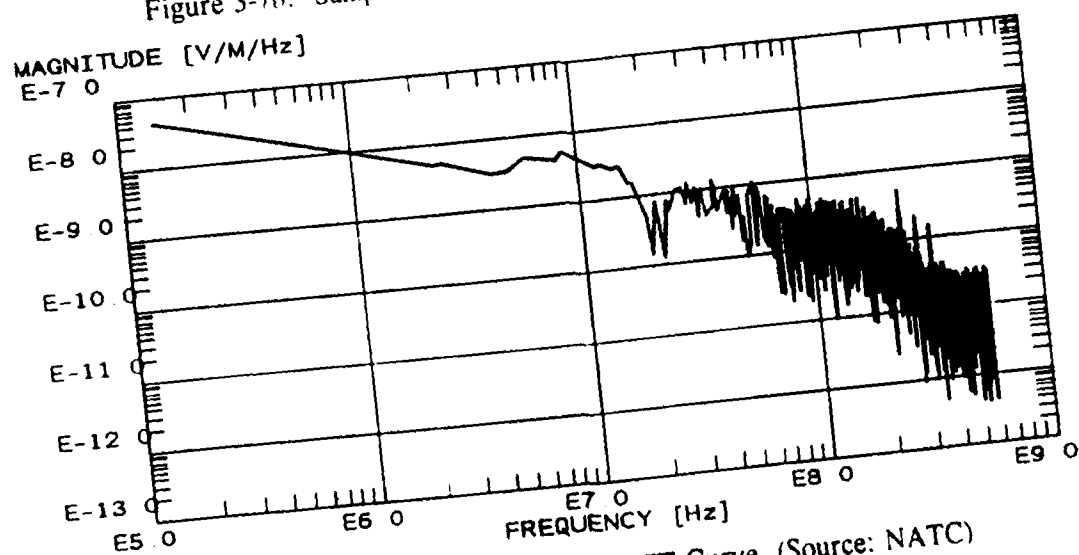h produces a certain amount of uncertainty in a given experimental value. That amount of uncertainty can then be predicted with a given probability. However, the population data samples for this report are not large; in fact, the test procedure was designed to yield a population data sample of four valid data points per change in parameter with a minimum acceptable number of valid data points being three. Hence, for this report, the error distribution is not Gaussian and no probability density function exists. It is sufficient, therefore, to try to minimize the source of random errors while also identifying the source of any suspected random errors and then calculating the amount of uncertainty introduced into the results.

3.2.1.1 Pulser Related Errors. The pulser discharges in a random manner about a certain given charge value. To minimize the effects of this pulser discharge error, all valid readouts of the reference sensor were normalized to the expected values for a given sensor boom location. This was necessary since neither of the test sensors were calibrated to give absolute value readings of the applied E-field. Hence, direct comparative readings could not be established.

3.2.1.2 Parameter Related Errors. Circumstances in this experiment limited the number of readings that could be taken for any given change in an experimental parameter. The parameters that were changed during the test were the boom location and angle of elevation, size of antenna on a given sensor, and orientation of the sensor antenna with respect to the EMP induced wave front.

A minimum of three data point distributions is required to determine the shape of the response curve over a given range of operation. Hence, the sensor boom was positioned at three locations along the perpendicular centerline. Additionally, for each position along the centerline, an attempt was made to obtain at least four valid data readouts for each sensor parameter change at that position. The test was primarily designed to determine the ability of the test sensors to track with the reference sensor over a given range of E-field intensities.

The randomness of the data plots due to the variation in boom locations (9, 20, and 33 m) and angle of inclination is absorbed into the method of least squares. The justification for using this method is based on the linear responses yielded in independent laboratory tests at both NIST and NRL on their respective sensors. There is no indication in the data that either test sensor system was saturated by the 50 kV/m intensity.

The size of a given antenna on a sensor probe was accounted for by scaling the responses of the sensor readouts. Again, the random errors introduced were minimized through the normalization and least squares method.

The last parameter to be accounted for was the 180° rotation of the dipole antennas on the NIST probe. The original intent was to record the output of the NIST sensor with an antenna in one orientation and then rotate the antenna through 180° to invert the detected EMP signal. By subtracting the signals from two opposite orientations, the EMP-related pulses would be additive and the internally generated random errors would, on the average, be subtractive. This is because internally generated sensor system

random errors tend to be in the same direction on a pulse-to-pulse basis while the externally generated EMP pulse is reversed with the reversal in antenna orientation. This antenna reversal procedure was performed only on the NIST sensor probe. However, the actual subtraction of errors was based on peak values only and not on the entire pulse distribution. Consequently, the NIST data was summed on a paired basis and divided by two. The paired data consisted of a readout with one antenna in the 0° orientation and a readout from the same physical location but with the antenna in the 180° orientation. This averaged both the NIST sensor readouts and the random error, but only minimized that portion of the internally generated random error that occurred during the small window when the peak values were determined by the digitizers.

3.2.2 Systematic Errors. Systematic errors are, in general, more difficult to detect than are random errors since they do not have a statistical distribution function. However, if the true value of an y experiment is known or, as in this case, a reference level is available, then the presence of a systematic error can be observed without actually knowing the cause.

Figure 3-3 illustrates the presence of a systematic error in that the three curves are laterally displaced from one another. With the D•Dot sensor readout being accepted as the reference readout, then the output of the NIST sensor system is systematically slightly higher and the NRL sensor system readout is systematically slightly lower. The smoothed output of the NIST sensor system is statistically insignificant from the output of the D•Dot sensor system.[1] However, the smoothed output of the NRL sensor system is significantly different from the output of the reference sensor in that there is an approximate 10% difference in readout values across the E-field intensity range.

Since all three sensor systems were calibrated at different times and at different locations with different sets of test equipment and in different environments, there is a high probability that the systematic error is one of sensor response calibration. The source of the systematic error in the NRL sensor system is an unknown factor at this time.

3.2.3 Other Errors. Although the number of pulser shots taken for each data set is neither a random nor systematic error, it has an impact on the statistical data. The limited number of shots used for each data set precluded the use of certain statistical methods of data analysis; i.e., the error distributions could not be considered to be Gaussian.

Based on previous tests conducted at the TES facility, it had been determined that there was a 25% probability of success in obtaining valid data on any given pulser discharge (shot). Hence, it was decided that at least 12 shots would be taken for each change in sensor parameter. With a 1:4 chance of success, this would yield 4 valid data points and provide a 33% margin of success.

While the pulser output was relatively constant, the variation in pulser output was a random error that affected the output of the sensors. To minimize the effect of this random variable, the reference sensor was normalized to one of three values, depending on the location of the sensor boom.

Finally, there are random errors introduced by pulser-induced EMI since the NIST sensor system was exposed to the pulser output and the NRL sensor system was routed through a trailer instead of

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[1] By *smoothed*, it is meant that the raw data from both the NIST and NRL sensor systems had to be calculated from their respective raw data by using the conversion factors supplied by the individual laboratories.

directly to the instrumentation van. As discussed earlier, the pulser-induced EMI in the NIST sensor electronics was accounted for to some extent by reversing the antenna orientation and subtracting the signal amplitudes in pairs. No equivalent attempt was made to reduce the random errors that might have been induced into the NRL sensor electronics due the fact that the electronics was located within the screened trailer instead of being located within the instrumentation van.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Upon analysis of the test data it is concluded that:

- The primary goal of using the modified NIST and NRL sensors for the measurement of EMP related E-Field parameters (field intensity, waveform shape, and frequency content) was achieved in the 1991 sensor field test.

- The NIST and NRL photonic sensors are suitable for further engineering development as EMP sensors.

- The consistency with which the electric field values of the NRL sensor are lower than those of the reference censor is indicative of a systematic error that has a high probability of being due to calibration procedures.

- The MetriCor sensor is not susceptible to EMP radiation in field strengths up to 50 kV/m.

- The MetriCor sensor system requires a change in operational concept before it can be used as an EMP measurement device although it may find use in measuring continuous wave E-fields where its inherent, total energy collection capability can be utilized.

- There was considerable difficulty in conducting a data analysis on the data gathered by three systems that were each calibrated at different times with different equipment and by different personnel.

It is recommended that work proceed on the R&D EMP sensor development plan which includes:

- Initiation of prototype sensor engineering development, that includes the planning and design for sensor miniaturization and packaging.

- Fabrication and testing of a prototype EMP sensor.

- Development of concepts for an embedded aircraft fiber optic sensor system for measuring EMP related to E-fields.

- Continuation of the assessment of photonics electromagnetic field sensor developments and identification of additional candidates for field test.

- Future tests of photonic sensor systems require prior calibration of all test sensors by the same activity prior to the initiation of EMP tests to minimize the discrepancies in test data readouts of the various sensor systems and to expedite the data analysis.

APPENDIX A

DESCRIPTION OF THE TEST SITE

A diagram of the HPD EMP simulator facility at NATC, Patuxent River, MD is shown in Figure A-1. This is a free-field pulse facility with a maximum RF signal well below the 100 kiloVolts/meter (kV/m) limit established for personnel exposure and presents no hazard to test personnel. The HPD uses a Maxwell Laboratories ML-5 pulser, a 5 MegaVolt (MV), dual Marx, single switch generator (pulser) type machine. The generator is contained in a low pressure, gas tight, fiberglass enclosure, approximately 5 meters long and 3 meters in diameter. The pulser is mounted in a biconic, cylindrical antenna which radiates a broadband, horizontally polarized RF signal. The pulser and antenna are suspended above an approximately 70 m diameter test pad to produce a uniformly illuminated test volume. Optimum propagation and illumination of the test volume is attained when the pulser is suspended at 30 meters above the center of the pad. Even though the pulser is capable of operating at 5 MV, its normal operating charge is 4 MV. At three meters above the ground and directly beneath the pulser, the antenna radiates an electric field close to 50 kV/m with an approximate 10 nanoseconds rise time. The HPD waveform approximates the unclassified High-Altitude Electromagnetic Pulse (HEMP).
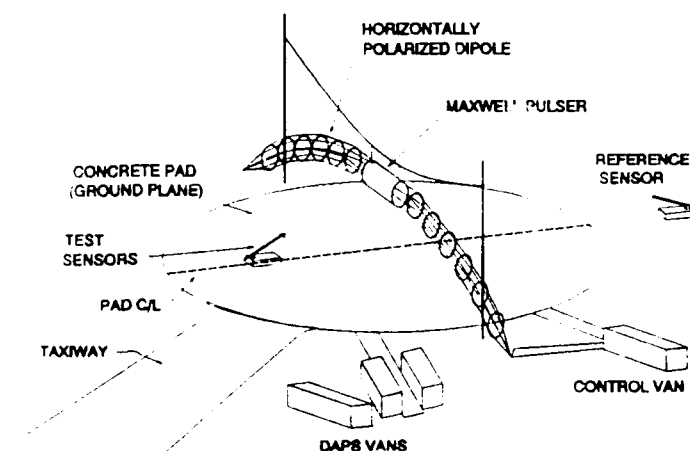

Figure A-1. EMP Site Diagram

Placement of the sensors for testing required locating points for which the approximate field was known relative to magnitude, nature, and symmetry (the emitted field is not spherically symmetrical). Obtaining definitive information concerning the field map proved to be difficult. Personnel at the site had only limited data, which they readily shared. Maxwell Laboratories engineers stated that the pulser generates a horizontally polarized E-field that is essentially a plane wave, and that the polarization of the field could be accurately predicted only along the centerline (C/L) of the pad, perpendicular to the pulser. They were not at all certain of the polarization of the field off the centerline. This established the test sensors orientation along the centerline of the pad with their dipoles parallel to the pulser. Considering this constraint, the available HPD field map data contained few usable field points which were along the pad centerline. The data for these few points were analyzed, extrapolated, and plotted to yield what proved to be a relatively accurate field map of the site along the centerline, shown in Figure 2-1.

The control van contains the equipment necessary to operate and monitor the pulser and serves as the coordination point for site safety. All data from sensors on the test pad is provided via optical cable for collection by automated equipment in the Data Acquisition and Processing System (DAPS) vans.

APPENDIX B
DESCRIPTION OF SENSORS

This appendix provides rudimentary descriptions of the D•Dot reference and all test sensors.

B.1 D•Dot Reference Sensor. This is a metallic E-field sensor that was used as a reference sensor for the tests covered by this report. This metallic sensor detects the rate of change of the electric flux density (D), which is directly related to the E-field vector E. Since the first derivative of a variable is often indicated by a dot over that variable, this measuring device is referred to as a D•Dot sensor. The disadvantages of the D•Dot instrument are:

(1)   The metallic sensor measures the rate of change of the E-field variable; hence its output must be electronically integrated to quantify the E-field.

(2)   By its metallic nature, the D•Dot sensor interacts with the applied EM field. This interaction may affect the measurement of the field.

(3)   The original coaxial signal cables from the B•Dot and D•Dot sensors were replaced by optical fiber to prevent coupling an induced signal into the Data Acquisition and Processing System (DAPS) instrumentation vans. This required the addition of electrical-to-optical conversion electronics adjacent to the sensor probes.

(4)   These sensors are relatively large and do not lend themselves to miniaturization and incorporation into aircraft structures as part of a networked sensor system.

B.2 NIST Photonic Sensor. NIST developed a photonic E-field sensor, funded by the U.S. Army Harry Diamond Laboratories, specifically for use in an EMP environment. The NIST sensor utilizes an electro-optic modulator of the Pockels cell type, incorporating a Bismuth Germanate, $Bi_4Ge_3O_{12}$.(BGO) bulk crystal and a 15 cm cylindrical, resistively tapered dipole. Unlike the D•Dot sensor, it measures the E-field intensity directly. Figure B-1 is a block diagram of the PEFM-15C, and Figure B-2 depicts the BGO bulk crystal modulator. The basic operating principle involved is the Linear Kerr Effect. Polarized light from a Diode Pumped Yttrium-Aluminum-Garnet (YAG) laser is uplinked through the BGO crystal through polarization maintaining fiber and related optics. An electric field alters the polarization angle of the light in a measurable amount which is directly related to the strength of the electric field. The light, after passing through the

Figure B-1. Block Diagram of the NIST Sensor System

crystal modulator, is downlinked to an interface unit which detects the change of polarization. Laboratory tests indicated a sensor frequency response from DC to above 2 GHz and a linear response in field strengths in excess of the nominal 50 kV/m of the HPD.

Cylindrical Resistively
Tapered Dipole

— Dielectric Mirror

Electro-Optic
Crystal

Optical Fiber
Mounting Post
Graded-Index Lens

$\lambda/8$ Retarder
Polarizing Beam
Splitter

Figure B-2. Bismuth Germanate Bulk Crystal Modulator

To ANTENNA

ELECTRODE

SINGLEMODE
CHANNEL
WAVEGUIDE

1.2°

To ANTENNA

Figure B-3. NRL Electro-Optic Modulator

B-2

B.3 NRL Photonic Sensor. The block diagram in Figure B-1 also describes the NRL sensor system. The modulator, shown in Figure B-3, is an integrated optic Mach-Zehnder (MZ) interferometer fabricated by Titanium diffusion on a Lithium Niobate (LiNbO₃) substrate. An applied voltage varies the optical refractive index in each arm of the MZ interferometer, modulating the optical throughput. An antenna is used to convert the E-field into the applied voltage. The antenna was replace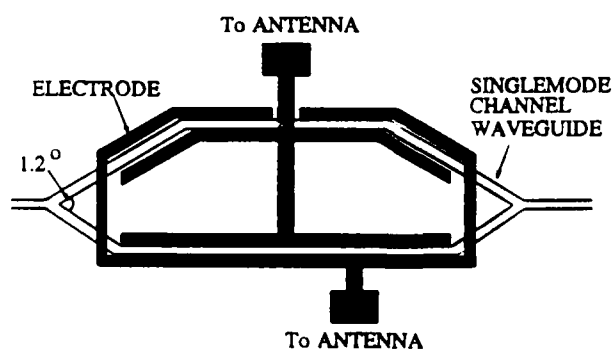able, and antennae from approximately 2 mm to 1.5 cm in length were used to vary the voltages applied across the crystal substrate. The modulator was packaged in a metal box of approximately 2.5cm x 7.5cm x 15cm with optical fibers for input and output.

B.4 MetriCor Fiber Optic Sensor. The MetriCor, Inc. sensor is shown in Figure B-4 and the sensor system is shown in Figure B-5. Heat generated by an applied current to a microdot of electrically resistive film is coupled to a commercial fiber optic SQUIB temperature sensor. For this application, an RF antenna provides the voltage to the SQUIB. A remote, fiber optic-coupled detector and signal processor converts the temperature induced wavelength shift in the optical sensor to a voltage readout.
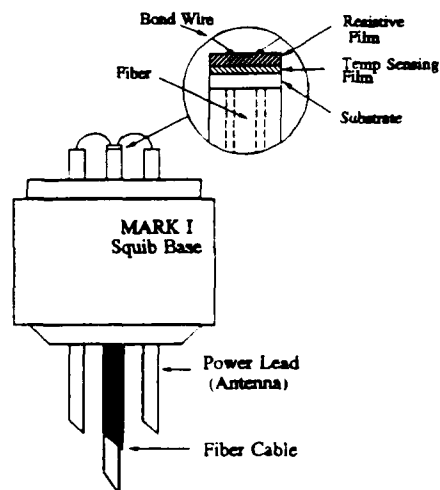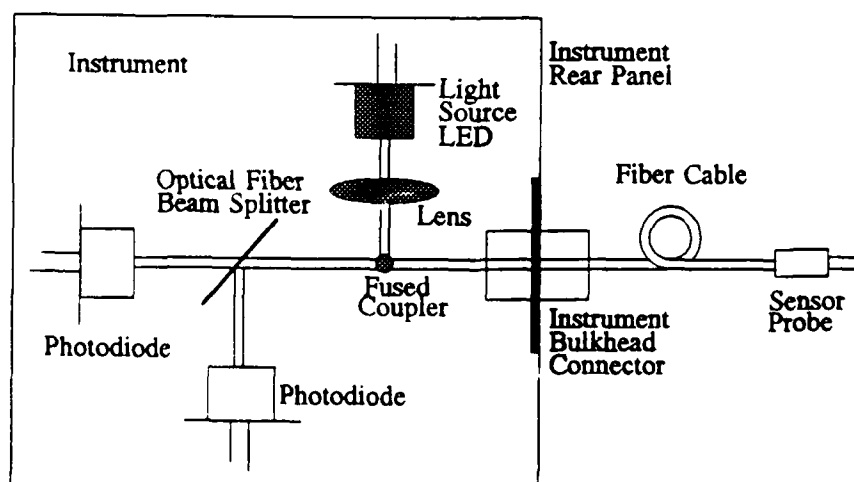

Figure B-4. MetriCor Sensor Diagram

Figure B-5. MetriCor Sensor System

APPENDIX C

SENSOR TEST SETUP

This appendix provides a diagram, Figure C-1, and description of the detailed test setup for the sensor systems tests. Availability of sufficient test monitoring equipment enabled the collocation and operation of all test sensors and the D•Dot reference sensor on the dielectric boom located on the test pad. The signal paths of the outputs of the D•Dot, NRL, and NIST sensors are described below. In each case, an optical signal was routed to the DAPS van. Inside the van, each was converted to an electrical signal to enable input to LeCroy 6880 Digitizers. The digitized signal was then passed to a computer with CATALYST software for collection and analysis. The MetriCor sensor output was routed as an optical signal directly to its dedicated interface unit in the DAPS van and then to a dedicated Personal Computer for data collection.

- The D•Dot sensor output was passed through an integrator and an Electrical-to-Optical (E-O) converter, both located on the boom, and then to the DAPS van.
- The NIST sensor output was routed through its interface unit to an E-O converter, both on the boom, and then via optical fiber to the DAPS van.
- The NRL sensor output was routed through its interface unit to an E-O converter, both located in a mobile office space adjacent to the DAPS van, and then via optical fiber to the DAPS van.
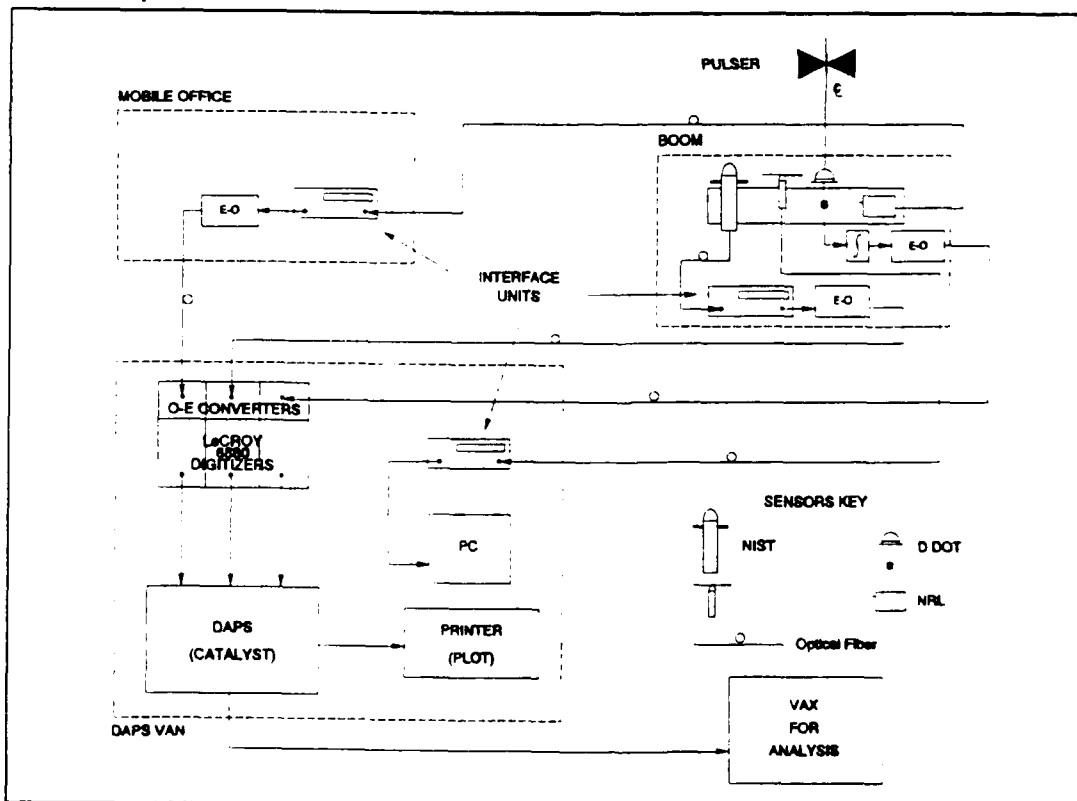
Figure C-1. Sensor Test Setup

APPENDIX D

CATALYST DATA CATALOG

This appendix is a catalog of the NATC-provided CATALYST presentation of the data collected during the 30 August 1990 photonic E-field sensor tests at the Horizontally Polarized Dipole EMP Simulator Facility at Naval Air Test Center, Patuxent River, MD. Both the recorded waveforms and their Fast Fourier Transforms are shown. This data is the basis for all analysis, conclusions and recommendations in this test report.

DDT00000 REPEAT 26, CORRECTED DATA

18 DEC 90 14 14 05   FILE DAG DATA DDT00000 0026 01 1 RAW
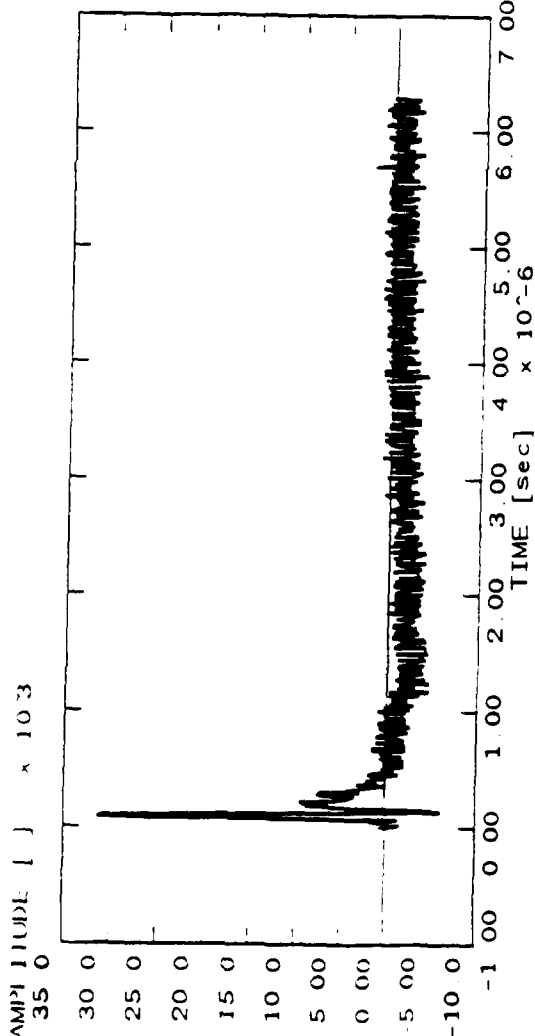
Test ID	ARC
Experiment Number	1
Pulse Number	14838
Pulse Date	30-AUG-1990 09 51 03
Quality	6
SIGNAL Peak [eu]	31 33 E+03
Peak Time [sec]	87 88 E-09
Rise Time [sec]	6 163 E-09
Decay Time (1/e) [sec]	41 75 E-09
Signal/Noise Ratio [dB]	29
Probe type	ACD-4
Probe Eu Conv factor	0 8854000E 11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [ ]   × 10^3

TIME [sec]   × 10^-6

MAGNITUDE [/Hz]
E-2.0

FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

D-2
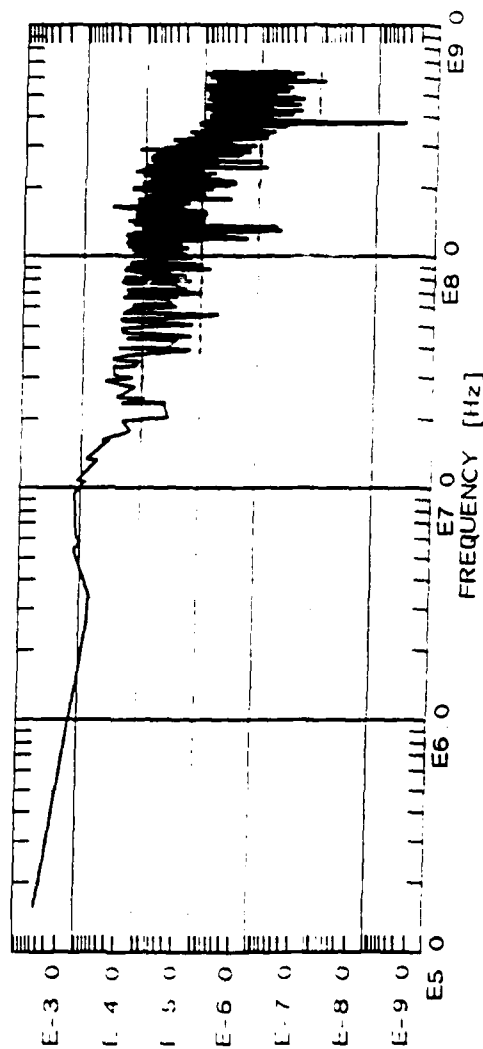
NRLOOOOO REPEAT 24, CORRECTED DATA

18 DEC 90 17 02 04   FILE DAS DATA NRLOOOOO 0024 02 1 RAW
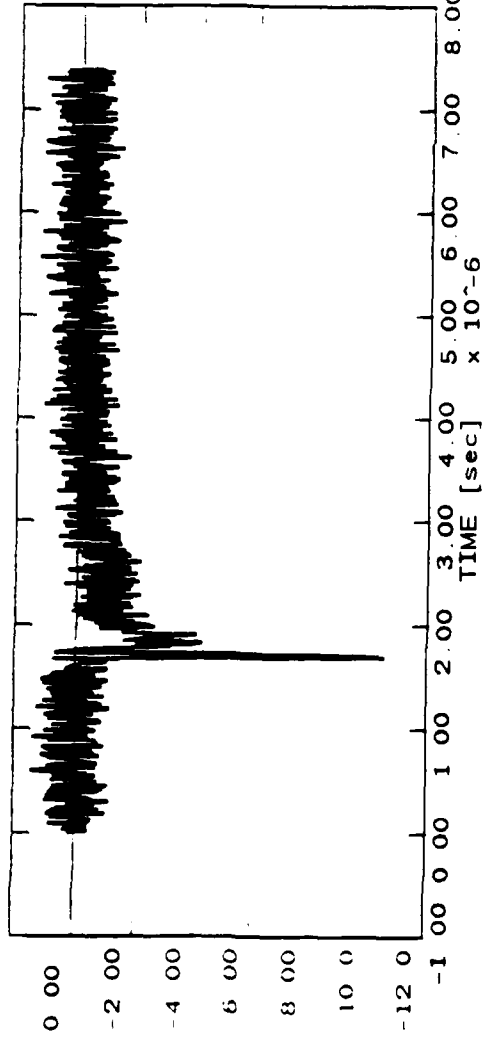
Test ID   ARC
Experiment Number   1
Pulse Number   14838
Pulse Date   30-AUG-1990 09 51 35
Quality   6
SIGNAL: Peak [V/M]   -10 48 E-03
          Peak Time [sec]   1.695 E-06
          Rise Time [sec]   10.59 E-09
          Decay Time (1/e) [sec]   0.216 E 06
          Signal/Noise Ratio [dB]   29

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

Transmitter Gain [db]   +31
Total Scalar Gain [db]   31

AMPLITUDE [V/M] × 10^-3
2 00

0 00

-2 00

-4 00

-6 00

-8 00

10 0

-12 0

-1 00 0 00 1 00 2 00 3 00 4 00 5 00 6 00 7 00 8 00
                              TIME [sec]
                              × 10^-6

MAGNITUDE [V/M/Hz]
E-8.0

E-9 0

I 10 0

I 11 0

E-12 0

E-13 0

E-14 0

E5 0   E6 0   E7 0   E8 0   E9 0
              FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

D-3

NIST0000 REPEAT 15, CORRECTED DATA

18 DEC 90 15 29 53

FILE DAS DATA NIST0000 0015 04 1 RAW

AMPLITUDE [V/M]   × 10^3
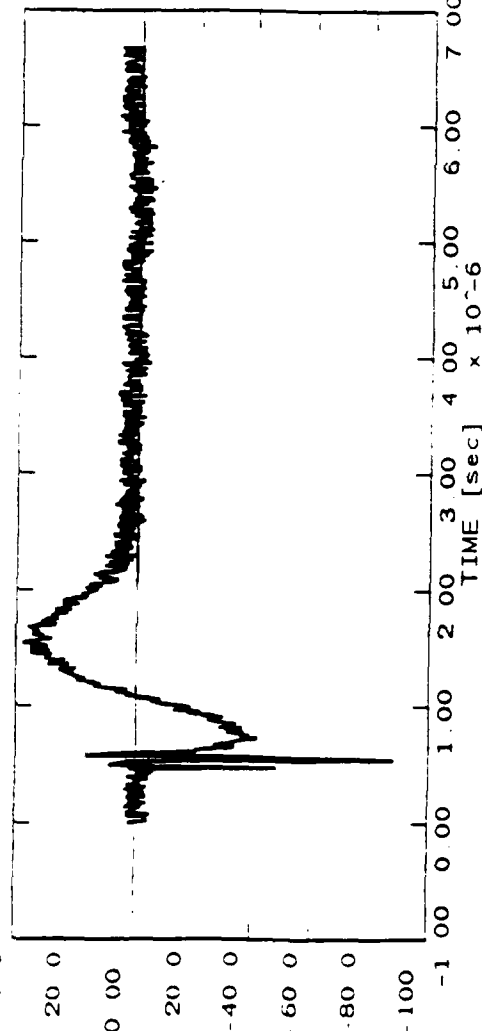
	Test ID	ARC
	Experiment Number	1
	Pulse Number	14038
	Pulse Date	30-AUG-1990 09 52 18
	Quality	6
SIGNAL	Peak [V/M]	8/ 67 E 03
	Peak Time [sec]	0 544 E-06
	Rise Time [sec]	8 457 E-09
	Decay Time (1/e) [sec]	1.164 E-06
	Signal/Noise Ratio [dB]	32
	Probe type	91550-2
	Probe Eu Conv factor	0.1000000E+01
	Transmitter Gain [db]	+9
	Total Scalar Gain [db]	9

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-4
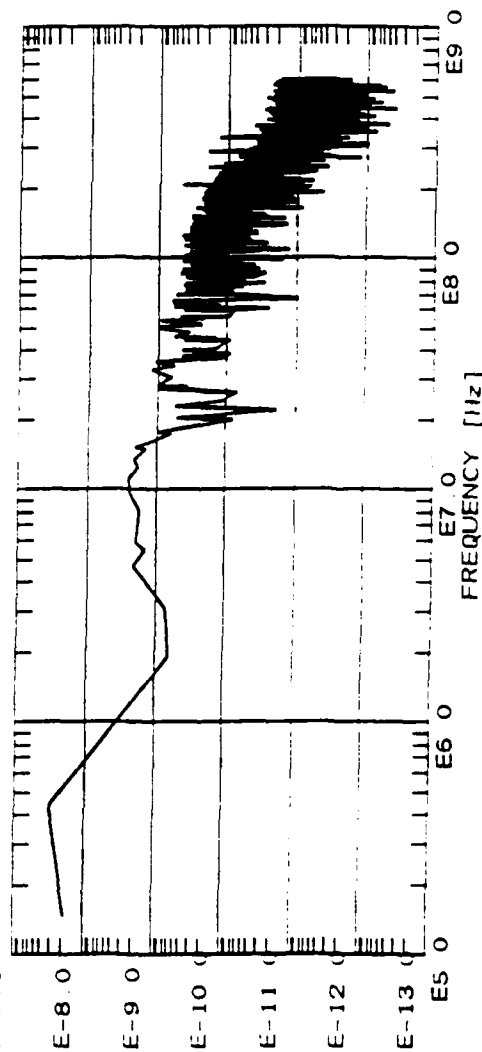
DDT00000 REPEAT 27, CORRECTED DATA

18-DEC-90 14 15 59   FILE DAS DATA DDT00000.0027.01 1 RAW

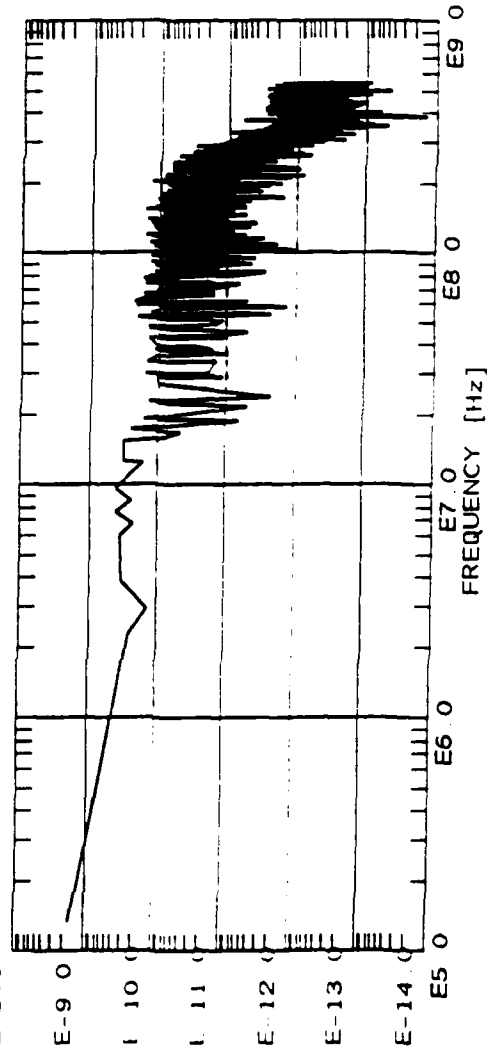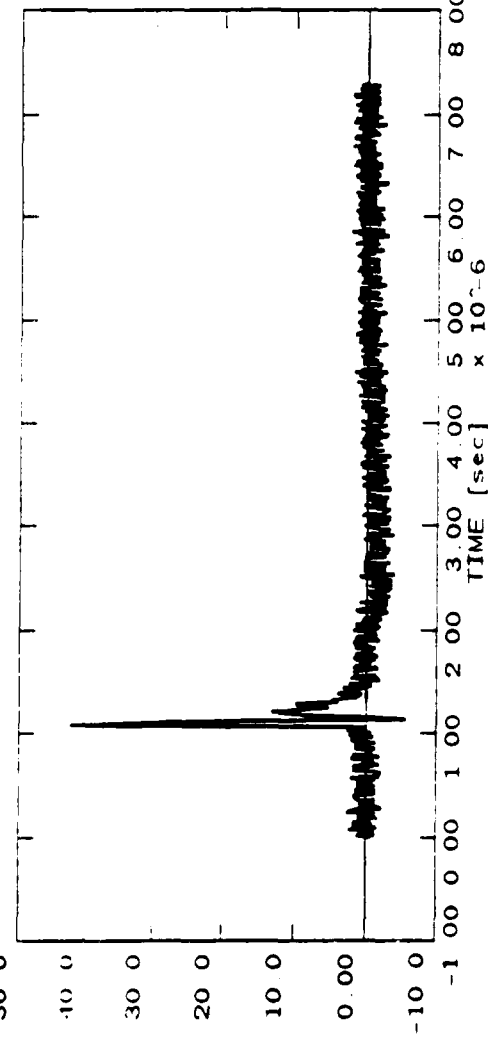Test ID   ARC
Experiment Number   1
Pulse Number   14839
Pulse Date   30-AUG-1990 10 03 02
Quality   6
SIGNAL: Peak [eu]   42 08 E+03
        Peak Time [sec]   1.090 E-06
        Rise Time [sec]   8.882 E-09
        Decay Time (1/e) [sec] 36.99 E-09
        Signal/Noise Ratio [dB] 33

Probe type   ACD-4
Probe Eu Conv. factor   0.8854000E-11
Transmitter Gain   [db]   +11
Total Scalar Gain   [db]   -102

AMPLITUDE [ ] x10^3
TIME [sec] x10^-6
MAGNITUDE [/Hz]
FREQUENCY [Hz]

D-5
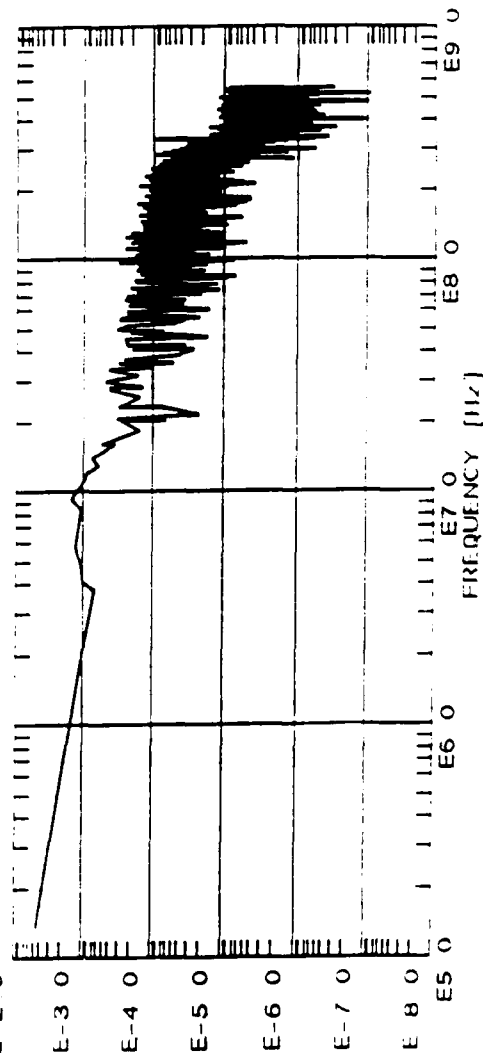
NRL00000 REPEAT 25, CORRECTED DATA

TITLE DAG DATA NRL00000 0025 02 1 RAW

AMPLITUDE [V/M] × 10^-3
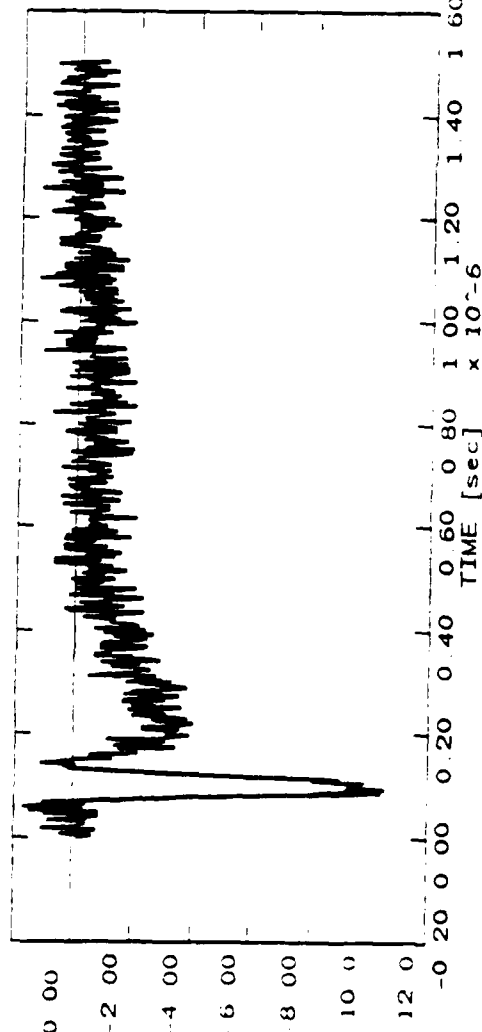
TIME [sec] × 10^-6

Test ID	ARC
Experiment Number	1
Pulse Number	14839
Pulse Date	30-AUG-1990 10 02 05
Quality	6
SIGNAL Peak [V/M]	-10 46 E-03
Peak Time [sec]	94 23 E-09
Rise Time [sec]	18 94 E-09
Decay Time (1/e) [sec]	0.127 E-06
Signal/Noise Ratio [dB]	22
Probe type	91550-2
Probe Eu Conv factor	0 1000000E+01
Transmitter Gain [db]	30
Total Scalar Gain [db]	30

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
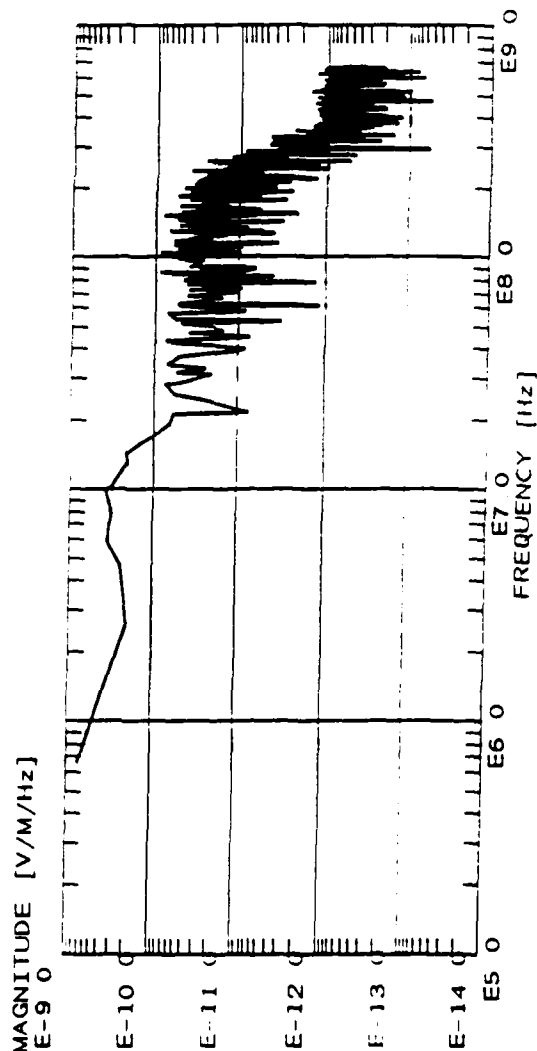
NIST0000 REPEAT 16, CORRECTED DATA

18-DEC-90 15 32 23   FILE DAS DATA NIST0000 0016 04 1 RAW
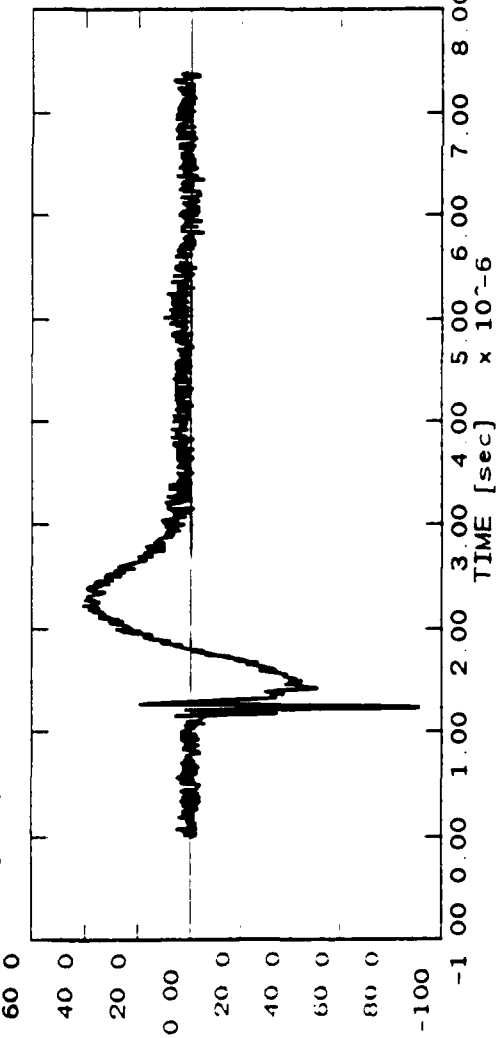
Test ID	ARC
Experiment Number	1
Pulse Number	14839
Pulse Date	30-AUG-1990 10.02 27
Quality	6
SIGNAL: Peak [V/M]	-91 17 E-03
Peak Time [sec]	1.241 E-06
Rise Time [sec]	7 251 E-09
Decay Time (1/e) [sec]	1 251 E-06
Signal/Noise Ratio [dB]	32
Probe type	91550-2
Probe Eu Conv factor	0 10000001.01
Transmitter Gain [db]	+9
Total Scalar Gain [db]	9

AMPLITUDE [V/M] $\times 10^{-3}$

TIME [sec] $\times 10^{-6}$

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-7
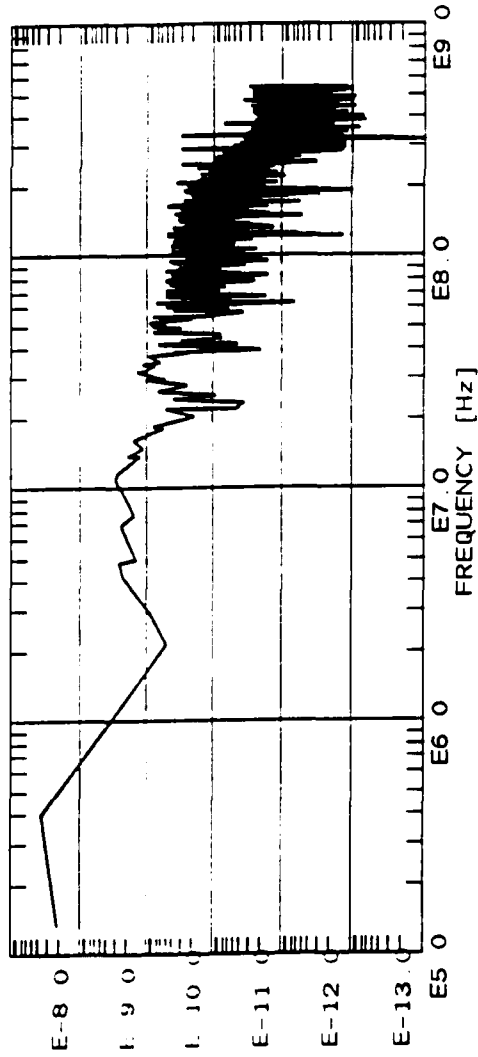
DDT00000 REPEAT 28, CORRECTED DATA

18-DEC-90 14 17 46   FILE DAS DATA DDT00000 0028 01 1 RAW
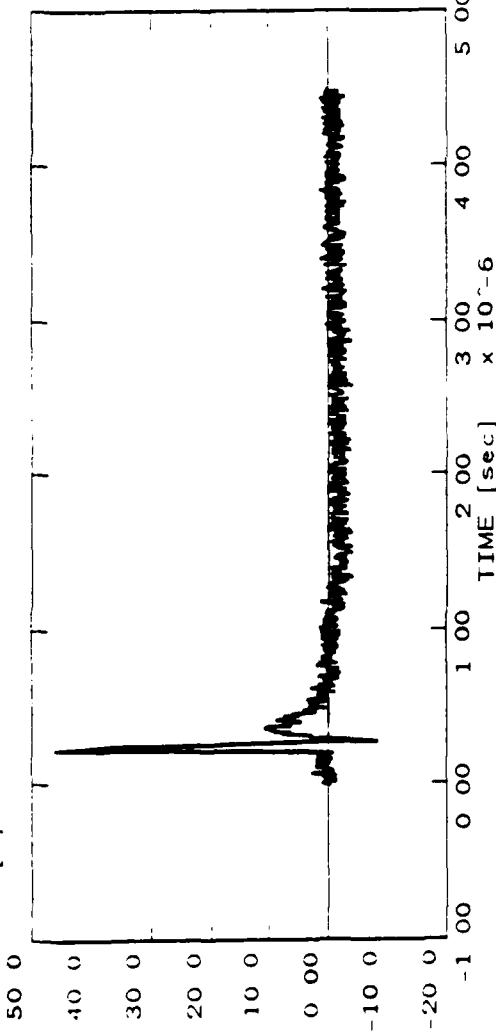
Test ID	ARC
Experiment Number	1
Pulse Number	14840
Pulse Date	30-AUG-1990 10 09 34
Quality	4
SIGNAL Peak [eu]	46 07 E+03
Peak Time [sec]	0 230 E-06
Rise Time [sec]	9 405 E-09
Decay Time (1/e) [sec]	36 47 E-09
Signal/Noise Ratio [dB]	34
Probe type	ACD-4
Probe Eu Conv factor	0 8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [ ]   × 10^3

TIME [sec]   × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

D-8
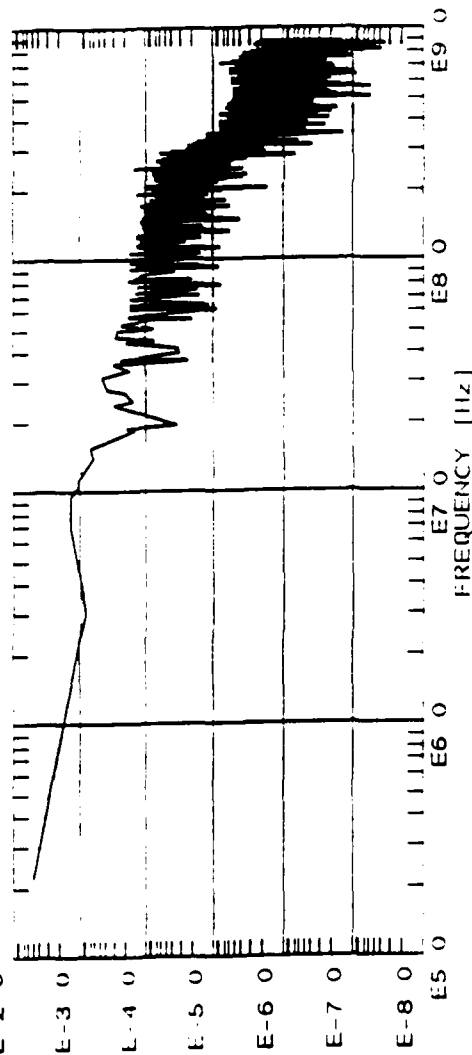
NRLOOOOO REPEAT 26, CORRECTED DATA

18 DEC 90 17 05 21   FILE DAS DATA NRI 00000 0026 02 1 RAW

AMPLITUDE [V/M] × 10^3
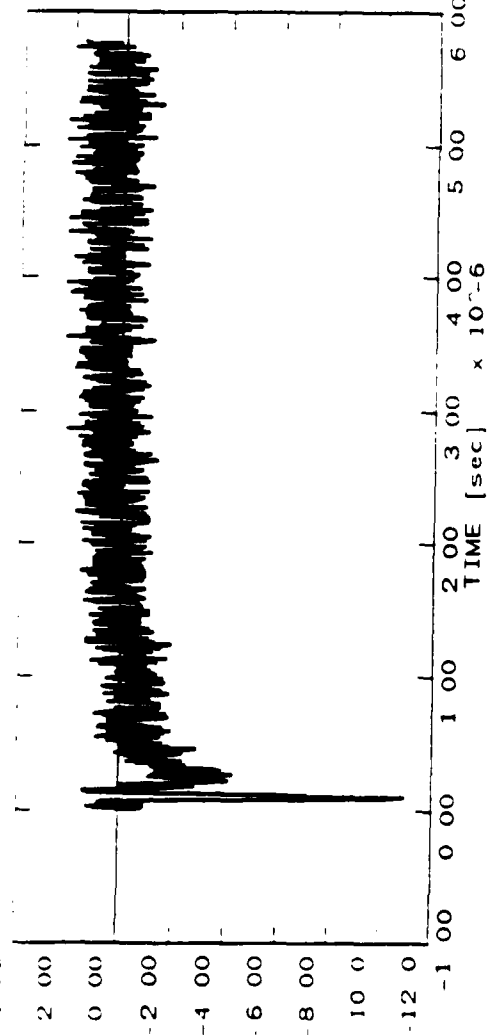
Test ID	ARC
Experiment Number	1
Pulse Number	14840
Pulse Date	30-AUG 1990 10 08 52
Quality	4
SIGNAL Peak [V/M]	10 87 E-03
Rise Time [sec]	0 103 E-06
Peak Time [sec]	27 75 E-09
Decay Time (1/e) [sec]	0.162 E-06
Signal/Noise Ratio [dB]	24
Probe type	91550-2
Probe Eu Conv factor	0 1000000E+01
Transmitter Gain [db]	+30
Total Scalar Gain [db]	30

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-9
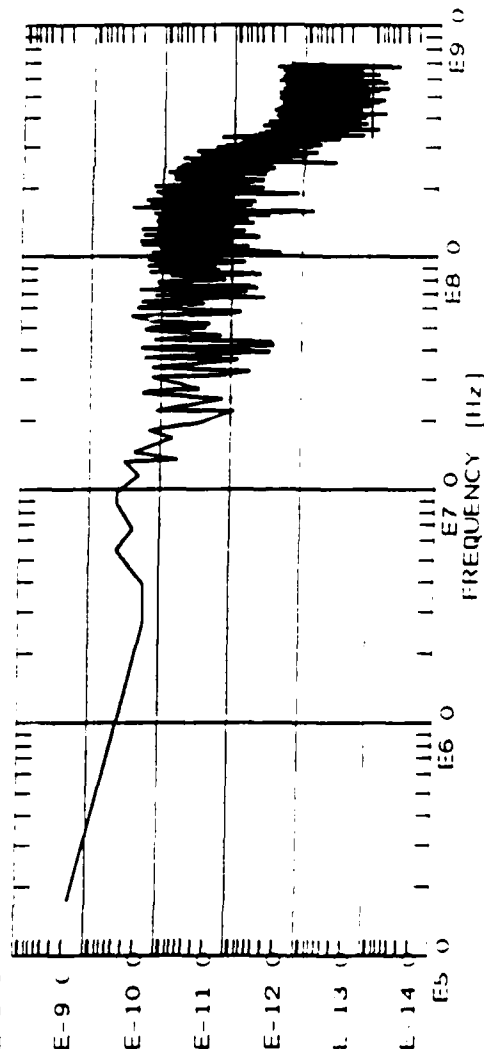
NISTOOOO REPEAT 17, CORRECTED DATA

18 DEC 90 15 35 04   FILE DAS DATA NISTOOOO 0017 04 1 RAW

Test ID   ARC
Experiment Number   1
Pulse Number   14840
Pulse Date   30-AUG-1990 10 09 13
Quality   4
SIGNAL   Peak [V/M]   -96 07 E-03
         Peak Time [sec]   0 147 E-06
         Rise Time [sec]   7 519 E-09
         Decay Time (1/e) [sec]   1 187 E-06
         Signal/Noise Ratio [dB]   29

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

Transmitter Gain [db]   49
Total Scalar Gain [db]   9

AMPLITUDE [V/M]   × 10^-3

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

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D-10

DDTO0000 REPEAT 29, CORRECTED DATA

18 DEC 90 14 19 30   FILE DAS DATA DDTO0000 0029 01 1 RAW
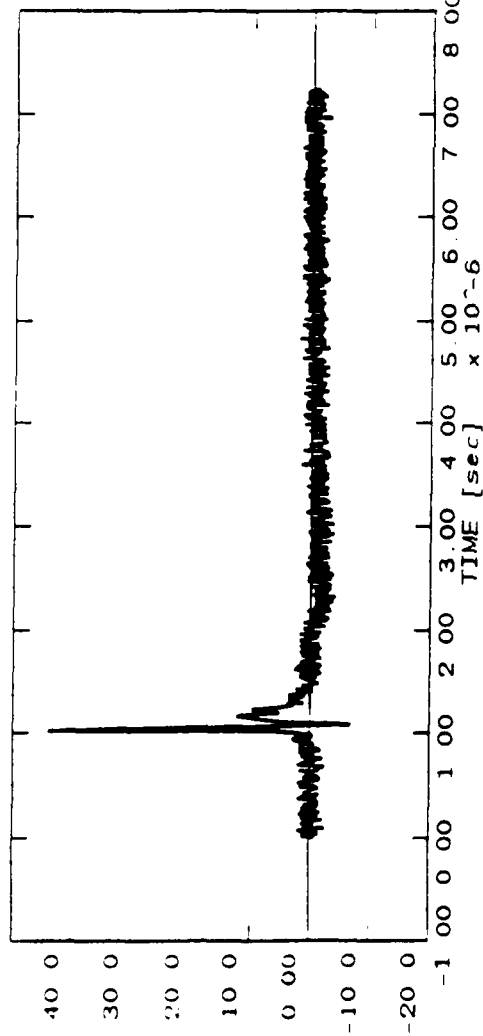
Test ID   ARC
Experiment Number   1
Pulse Number   14841
Pulse Date   30-AUG-1990 10 15 38
Quality   6
SIGNAL Peak [eu]   43 90 E+03
        Peak Time [sec]   1.033 E-06
        Rise Time [sec]   8 632 E-09
        Decay Time (1/e) [sec]   36 89 E-09
        Signal/Noise Ratio [dB]   33

Probe type   ACD-4
Probe Eu Conv factor   0 8854000E-11

Transmitter Gain   [db]   +11
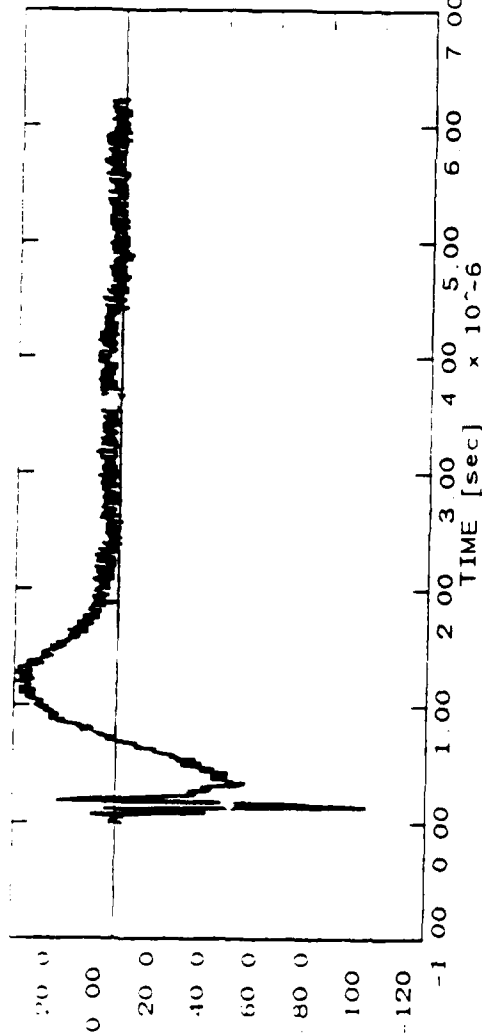Total Scalar Gain [db]   -102

FOR OFFICIAL USE ONLY

NRL00000 REPEAT 27, CORRECTED DATA

TITLE: DATA, DATA NRL00000 0027 02 1 RAW

18 DEC 90 17 06 58

AMPLITUDE [V/M]   × 10^-3

Test ID   ARC
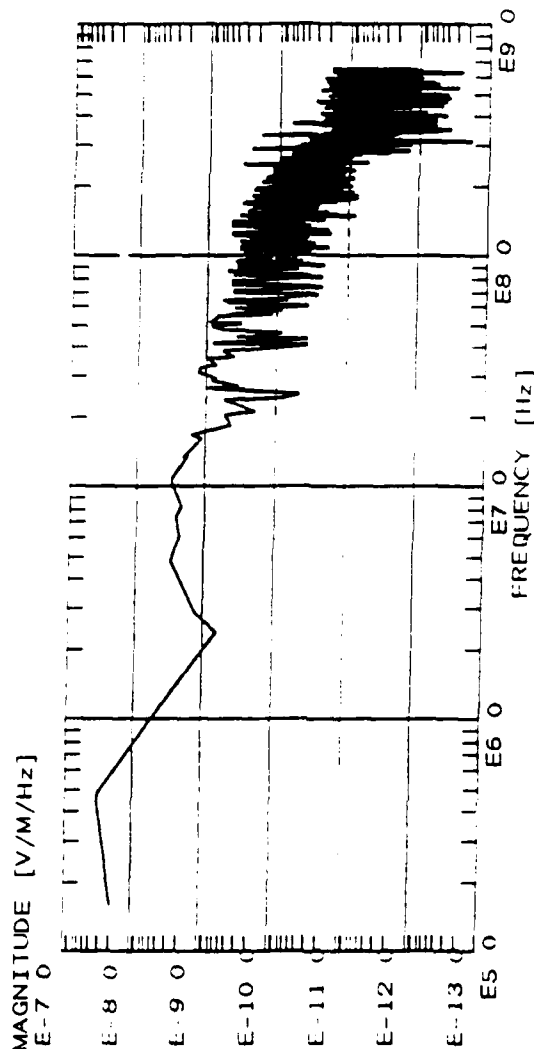Experiment Number   1
Pulse Number   14841
Pulse Date   30-AUG-1990 10 14 43
Quality   6
SIGNAL   Peak [V/M]   10.92 E-03
         Peak Time [sec]   0.107 E-06
         Rise Time [sec]   30.01 E-09
         Decay Time (1/e) [sec]   0.193 E 06
         Signal/Noise Ratio [dB]   25

Probe type   91550-2
Probe Eu Conv factor   0.1000000E+01

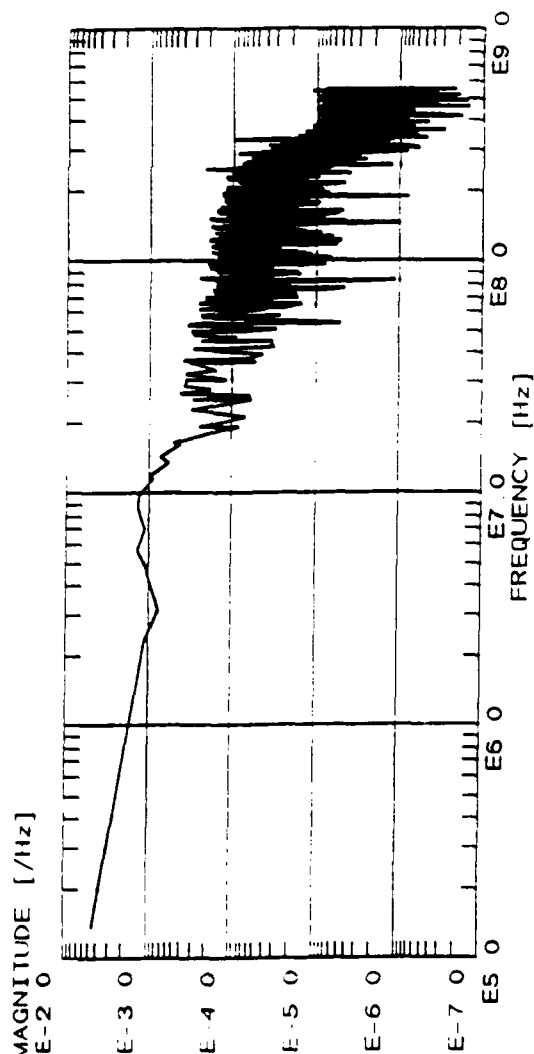Transmitter Gain   [db]   ·28
Total Scalar Gain   [db]   28

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-12
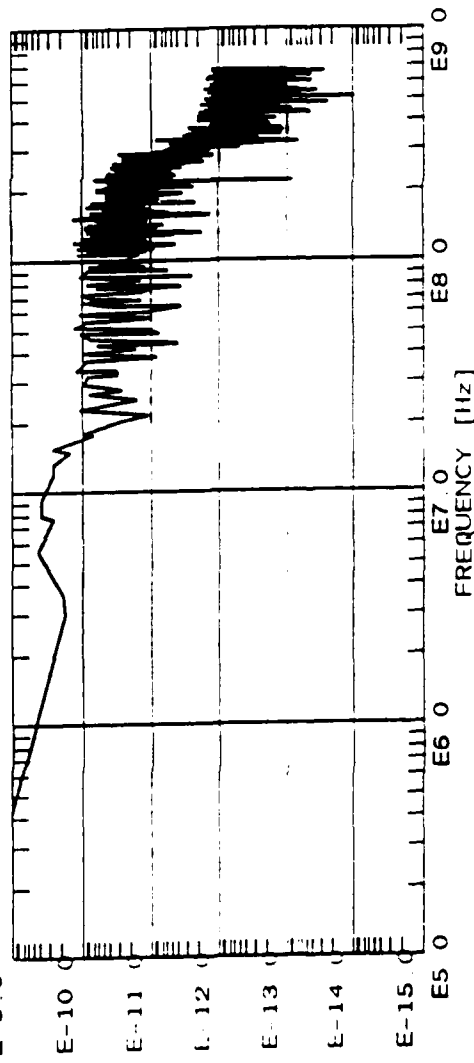
NIST0000 REPEAT 18, CORRECTED DATA

18-DEC-90 15:36:51   FILE DAS DATA NIST0000 0018 04 1 RAW
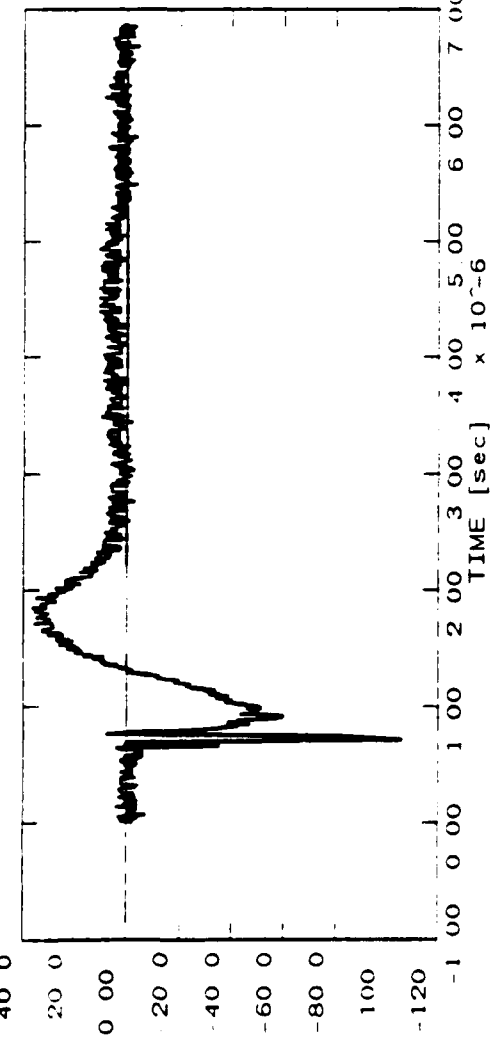
Test ID   ARC
Experiment Number   1
Pulse Number   14841
Pulse Date   30-AUG-1990 10:15:19
Quality   6
SIGNAL: Peak [V/M]   0.105
        Peak Time [sec]   0.722 E-06
        Rise Time [sec]   7.790 E-09
        Decay Time (1/e) [sec]   0.343 E-06
        Signal/Noise Ratio [dB] 33

Probe type   91550-2
Probe Eu Conv factor   0.1000000E+01

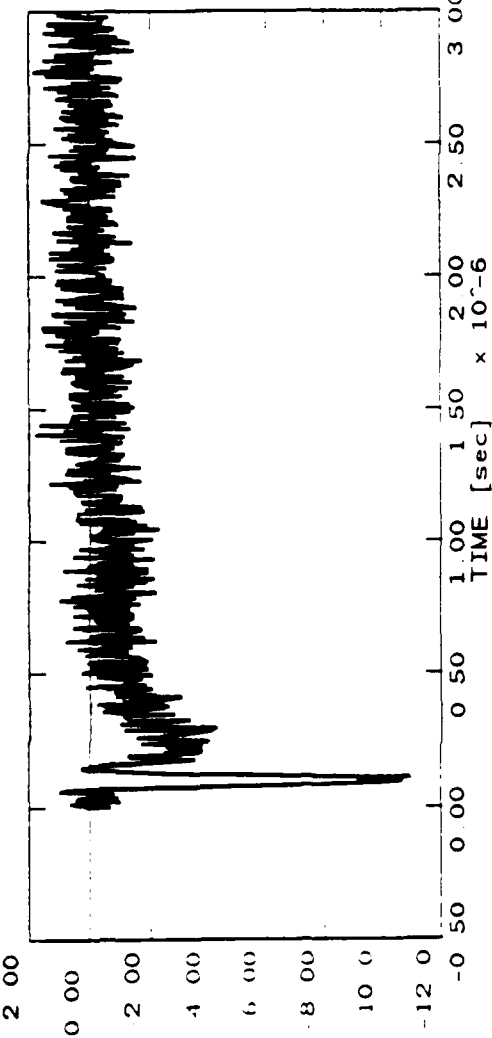Transmitter Gain [db]
Total Scalar Gain [db]

AMPLITUDE [V/M] × 10⁻³

TIME [sec] × 10⁻⁶

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
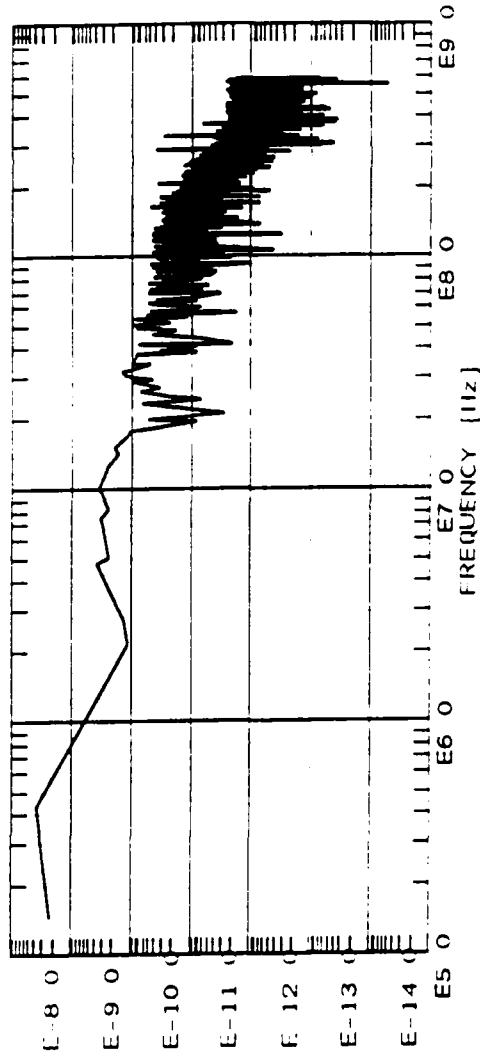
DDT00000 REPEAT 30, CORRECTED DATA

18 DEC 90   14 21 12   FILE DAS DATA DDT00000 0030 01 1 RAW
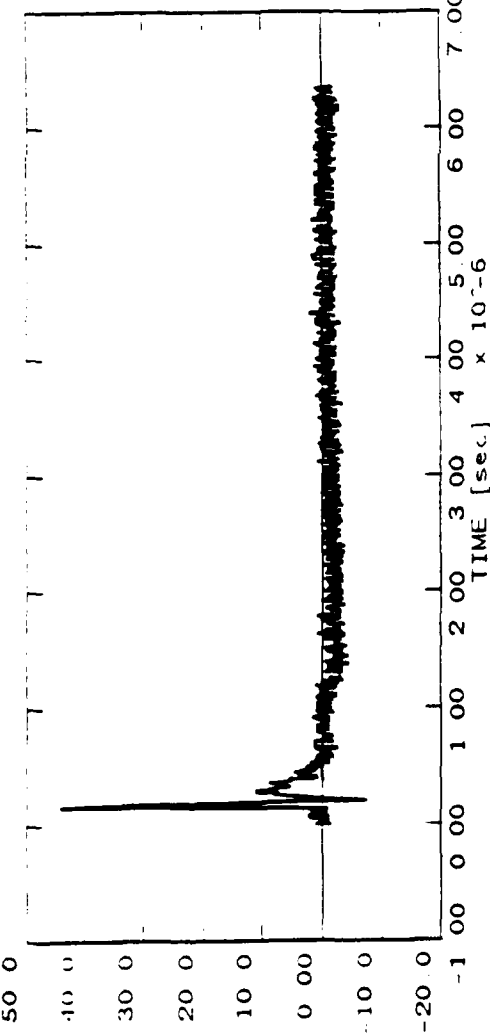
Test ID   ARC
Experiment Number   1
Pulse Number   14842
Pulse Date   30-AUG 1990 10 22 49
  Quality   6
SIGNAL   Peak [eu]   44.21 E+03
         Peak Time [sec]   0.160 E-06
         Rise Time [sec]   9 785 E-09
         Decay Time (1/e) [sec] 36 38 E-09
         Signal/Noise Ratio [dB] 32

Probe type   ACD-4
Probe Eu Conv factor   0 8854000E-11

Transmitter Gain [db]   +11
Total Scalar Gain [db]   -102

AMPLITUDE [-]   × 10^3

MAGNITUDE [/Hz]

FREQUENCY [Hz]

TIME [sec.]   × 10^-6

FOR OFFICIAL USE ONLY

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NRLOOOOO REPEAT 28, CORRECTED DATA

18-DEC-90 17 08 39   FILE DAS DATA NRLOOOOO 0028 02 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14842
Pulse Date	30-AUG-1990 10 21 54
Quality	6
SIGNAL: Peak [V/M]	-10 41 E-03
Peak Time [sec]	0.101 E-06
Rise Time [sec]	17.71 E-09
Decay Time (1/e) [sec]	0.180 E-06
Signal/Noise Ratio [dB]	24
Probe type	91550-2
Probe Eu Conv factor	0.1000000E+01
Transmitter Gain [db]	+28
Total Scalar Gain [db]	28

D-15
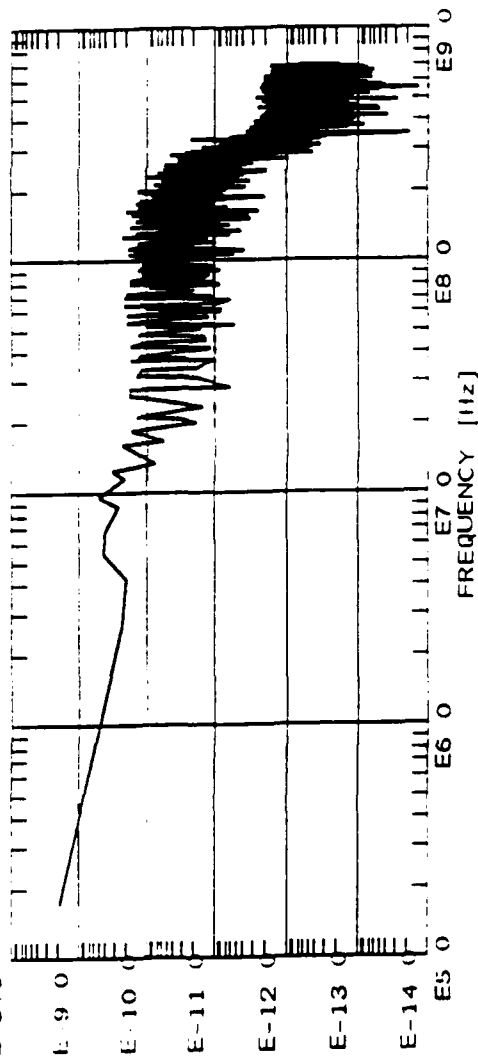
NIST0000 REPEAT 19, CORRECTED DATA

18 DEC 90   15 38 47   FILE DAS DATA NIST0000 0019 04 1 RAW

AMPLITUDE [V/M]   × 10^-3
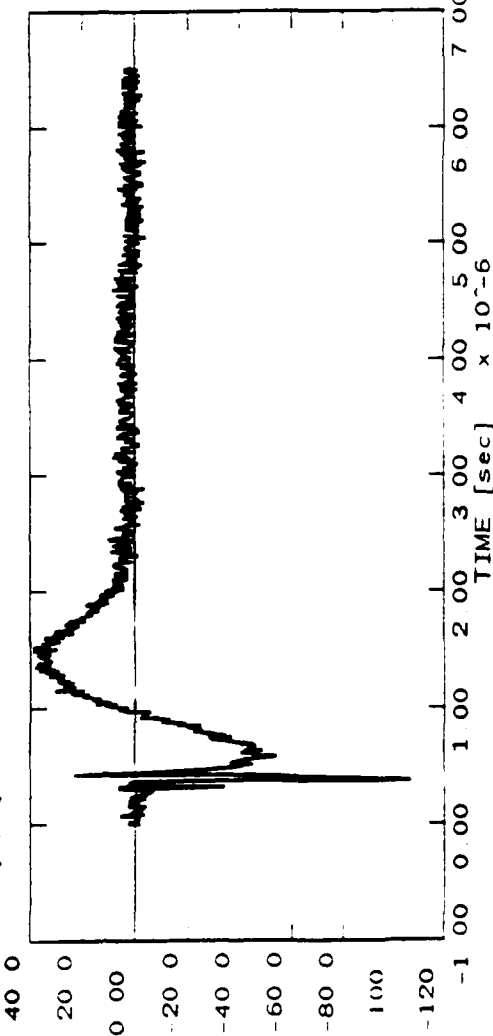
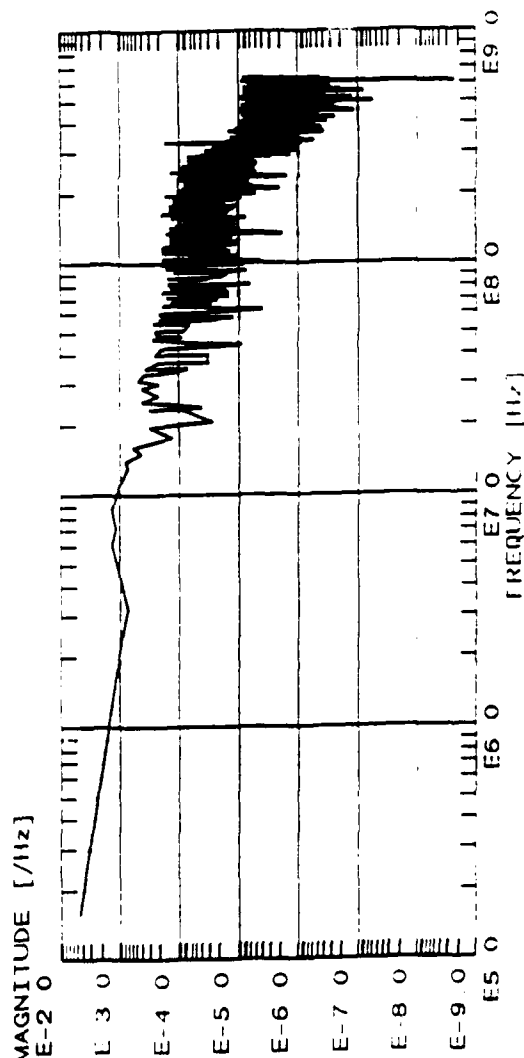Test ID   ARC
Experiment Number   1
Pulse Number   14842
Pulse Date   30-AUG-1990 10.22.30
Quality   6
SIGNAL: Peak [V/M]   -0 106
         Peak Time [sec]   0 386 E-06
         Rise Time [sec]   7 296 E-09
         Decay Time (1/e) [sec] 0 321 E-06
         Signal/Noise Ratio [dB] 34

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01
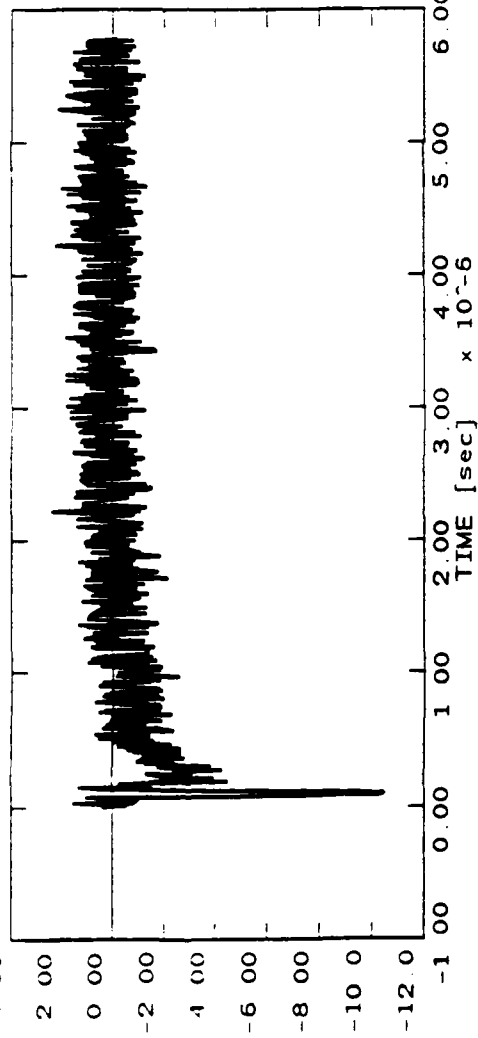Transmitter Gain [db]   19
Total Scalar Gain [db]   9

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
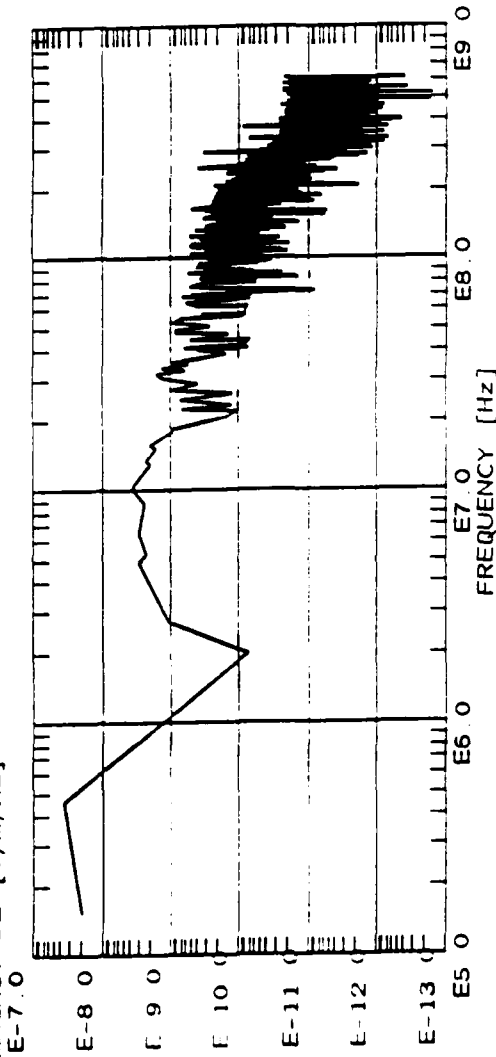
DDT00000 REPEAT 31, CORRECTED DATA

18 DEC 90   14 23 03   FILE DAS DATA DD100000 0031 01 1 RAW
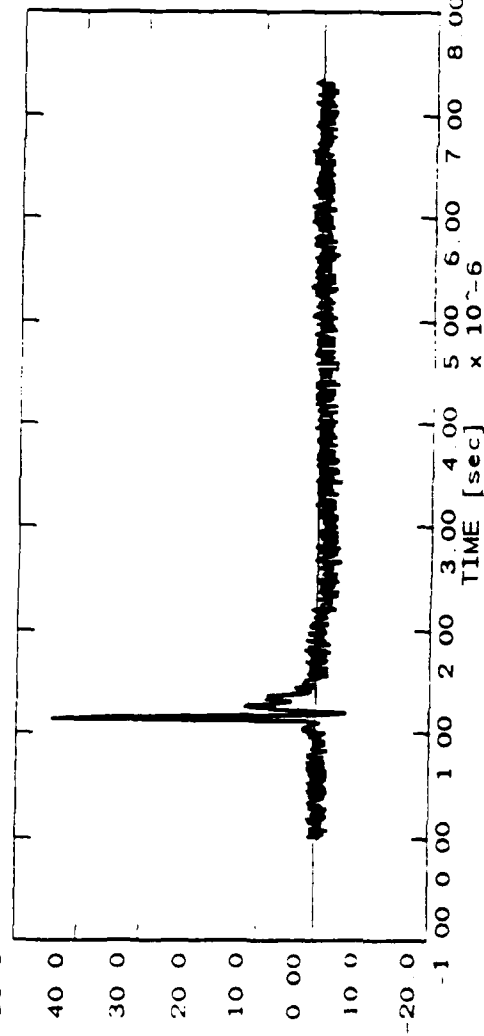
Test ID	ARC
Experiment Number	1
Pulse Number	14843
Pulse Date	30-AUG-1990 10 32 13
Quality	6

SIGNAL

Peak [eu]	44 06 E+03
Peak Time [sec]	1 146 E-06
Rise Time [sec]	9 247 E-09
Decay Time (1/e) [sec]	38 30 E-09
Signal/Noise Ratio [dB]	33

Probe type	ACD-4
Probe Eu Conv factor	0 88540000L 11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [ ] × 10^3

50 0
40 0
30 0
20 0
10 0
0 00
10 0
-20 0
-1 00 0 00   1 00   2 00   3 00   4 00   5 00   6 00   7 00   8 00
TIME [sec] × 10^-6

MAGNITUDE [/Hz]

E-2.0
E-3.0
E-4.0
E 5 0
E-6.0
E 7 0
E-8 0
E5 0   E6 0   E7 0   E8 0   E9 0
FREQUENCY [Hz]

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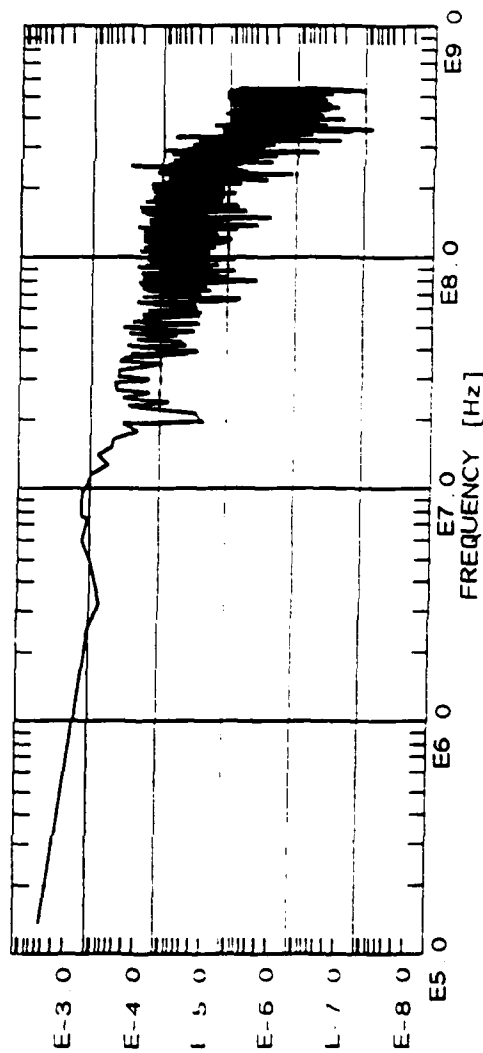
NRL00000 REPEAT 29, CORRECTED DATA

18 DEC 90 17 10 20   FILE DAS DATA NRL00000 0029 02 1 RAW

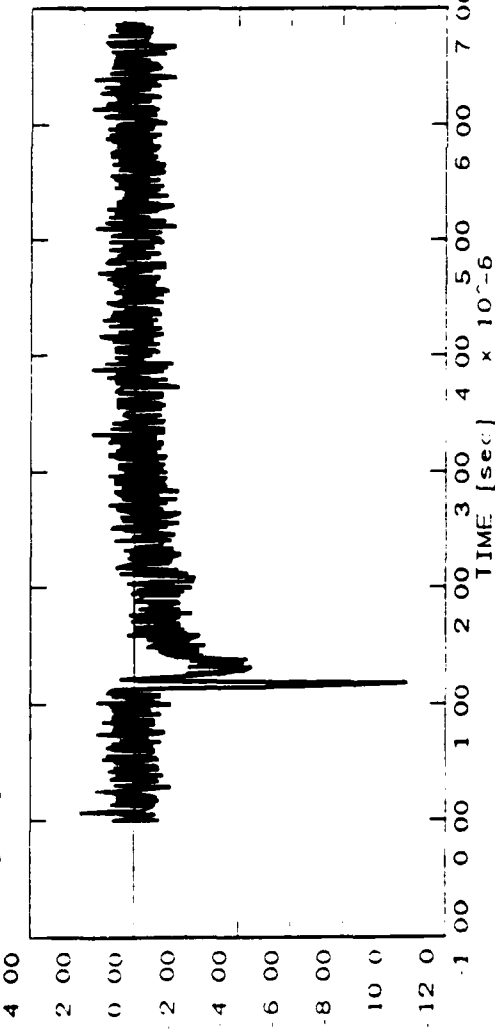Test ID   ARC
Experiment Number   1
Pulse Number   14843
Pulse Date   30-AUG 1990 10 32 29
Quality   6
SIGNAL   Peak [V/M]   10.43 E-03
         Peak Time [sec]   1.190 E-06
         Rise Time [sec]   25.13 E-09
         Decay Time (1/e) [sec]   0.208 E-06
         Signal/Noise Ratio [dB]   24

Probe type   91550-2
Probe Eu Conv factor   0 10000000.01
Transmitter Gain [db]   128
Total Scalar Gain [db]   28

AMPLITUDE [V/M]   × 10^3

4 00
2 00
0 00
-2 00
-4 00
-6 00
-8 00
10 0
-12 0

-1 00   0 00   1 00   2 00   3 00   4 00   5 00   6 00   7 00
                          TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]
E 8 0
E 9 0
E 10 0
E 11 0
E 12 0
E 13 0
E-14 0
E5 0

E6 0   E7 0   E8 0   E9 0
        FREQUENCY [Hz]

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NIST0000 REPEAT 20, CORRECTED DATA

18 DEC 90   15 40 51   FILE DAS DATA NIST0000 0020 04 1 RAW

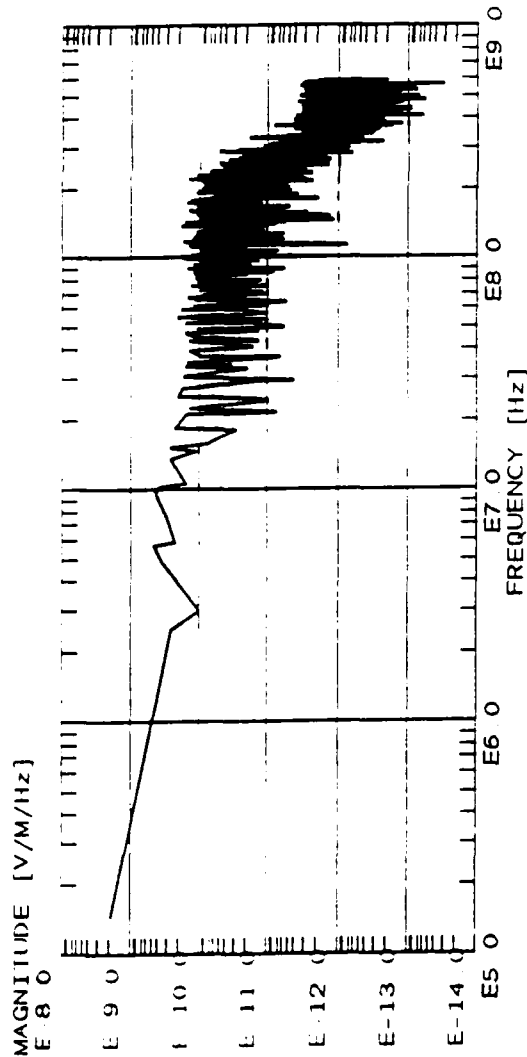Test ID   ARC
Experiment Number   1
Pulse Number   14843
Pulse Date   30-AUG 1990 10 32 44
Quality   6
SIGNAL Peak [V/M]   94 63 E-03
        Peak Time [sec]   1 143 E-06
        Rise Time [sec]   8 539 E-09
        Decay Time (1/e) [sec]   1 197 E-06
        Signal/Noise Ratio [dB] 33

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

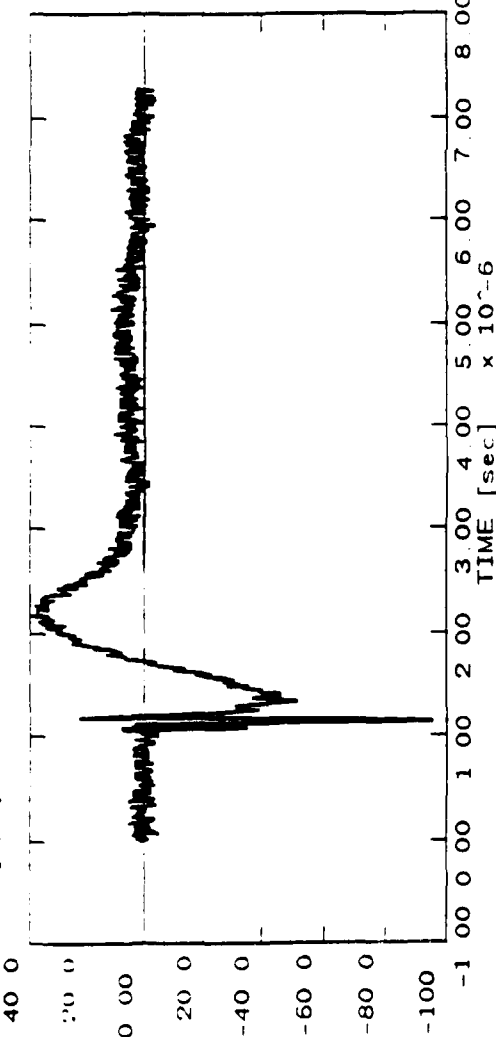Transmitter Gain [db]   +9
Total Scalar Gain [db]   9

DDT00000 REPEAT 34, CORRECTED DATA

Test ID   ARC
Experiment Number   1
Pulse Number   14846
Pulse Date   30-AUG-1990 11 03 39
Quality   4
SIGNAL: Peak [eu]   43.97 E+03
        Peak Time [sec]   0.146 E-06
        Rise Time [sec]   8.497 E-09
        Decay Time (1/e) [sec]   37 99 E-09
        Signal/Noise Ratio [dB] 35

Probe type   ACD-4
Probe Fu Conv factor   0 885-10000 11
Transmitter Gain   [db]   111
Total Scalar Gain   [db]   -102

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NRL 00000 REPEAT 32, CORRECTED DATA

18 DEC 90 17 15 24   FILE DAC DATA NRL 00000 0032 02 1 RAW

AMPLITUDE [V/M]   x 10^-3

Test ID	ARC
Experiment Number	1
Pulse Number	14846
Pulse Date	30-AUG-1990 11 02:16
Quality	4
SIGNAL Peak [V/M]	1 191 E-03
Peak Time [sec]	6 449 E-06
Rise Time [sec]	2 992 E-09
Decay Time (1/e) [sec]	0 912 E-06
Signal/Noise Ratio [dB]	8
Probe type	91550 2
Probe Eu Conv factor	0 10000000 01
Transmitter Gain [db]	28
Total Scalar Gain [db]	28

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-21

NIST0000 REPEAT 21, CORRECTED DATA

18-DEC-90 15:44:14

FILE: DAS DATA NIST0000 0021 04 1 RAW

AMPLITUDE [V/M] × 10^-3

Test ID   ARC
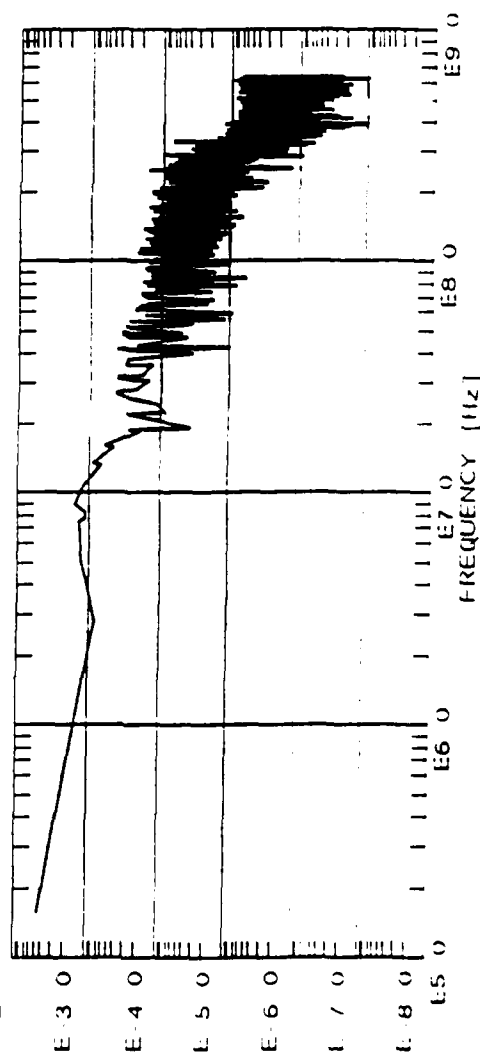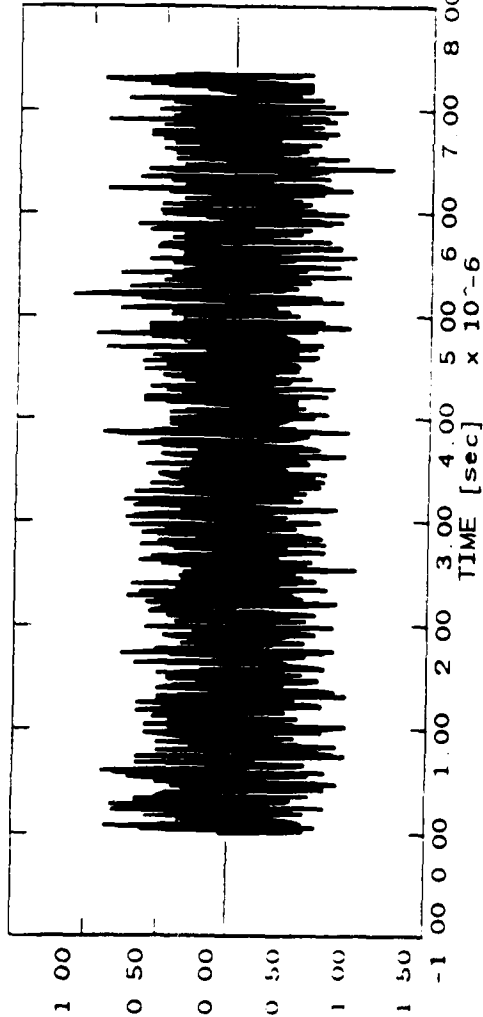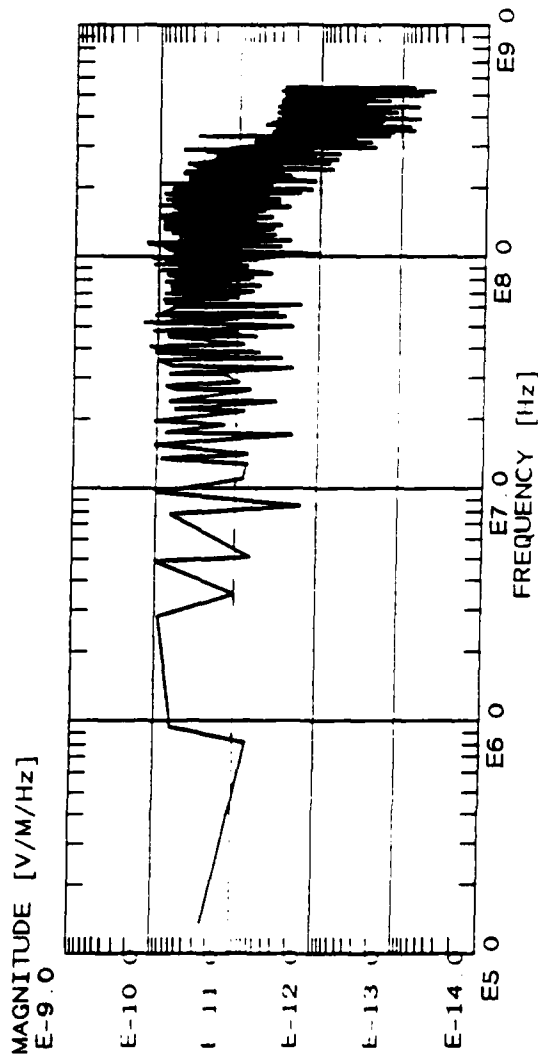Experiment Number   1
Pulse Number   14846
Pulse Date   30 AUG 1990 11:03:10
Quality   4
SIGNAL   Peak [V/M]   0.126
         Peak Time [sec]   1.223 E-06
         Rise Time [sec]   7.835 E-09
         Decay Time (1/e) [sec]   1.062 E-06
         Signal/Noise Ratio [dB]   36

Probe type   91550-2
Probe Eu Conv factor   0.100000E+01

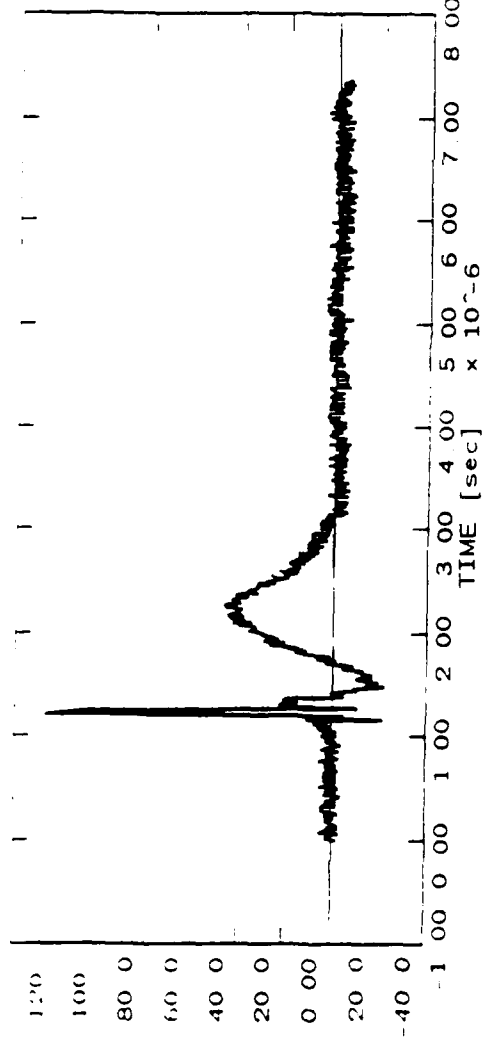Transmitter Gain [db]   +9
Total Scalar Gain [db]   9

TIME [sec]

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
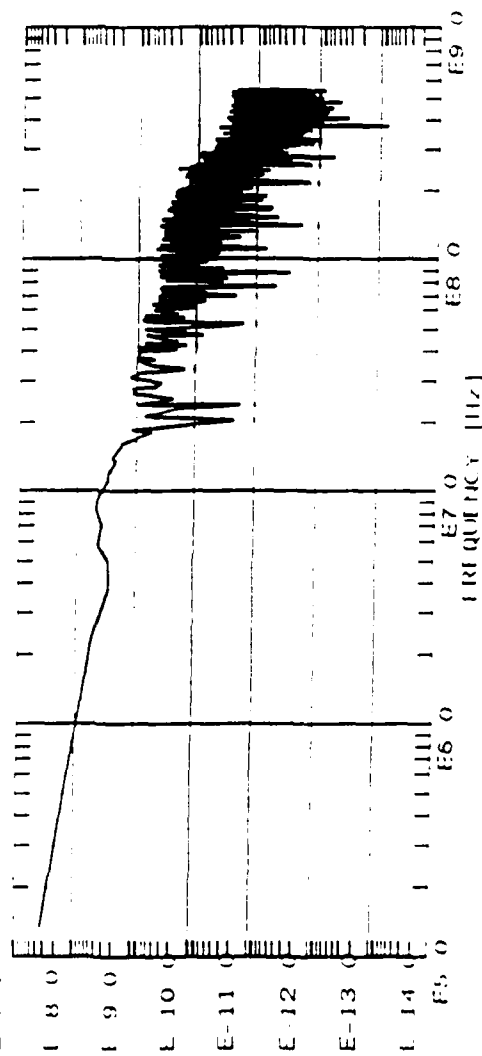
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DDT00000 REPEAT 35, CORRECTED DATA

18 DEC 90 14:31:02   FILE DAS DATA DDT00000 0035 01 1 RAW
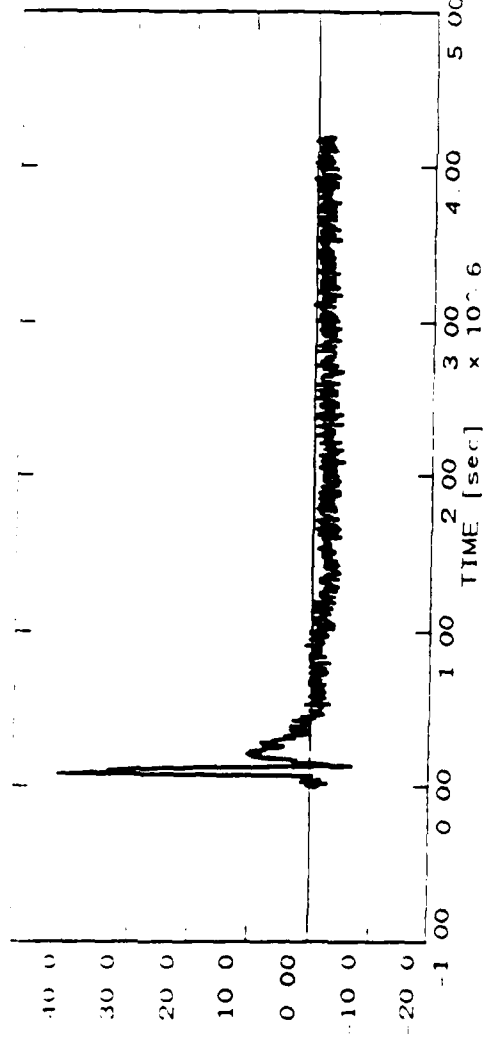
Test ID	ARC
Experiment Number	1
Pulse Number	14847
Pulse Date	30-AUG 1990 11:10:15
Quality	6
SIGNAL Peak [eu]	42.12 E+03
Peak Time [sec]	88.41 E-09
Rise Time [sec]	9.846 E-09
Decay Time (1/e) [sec]	37.74 E-09
Signal/Noise Ratio [dB]	31
Probe type	ACD-4
Probe Eu Conv factor	0.8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102
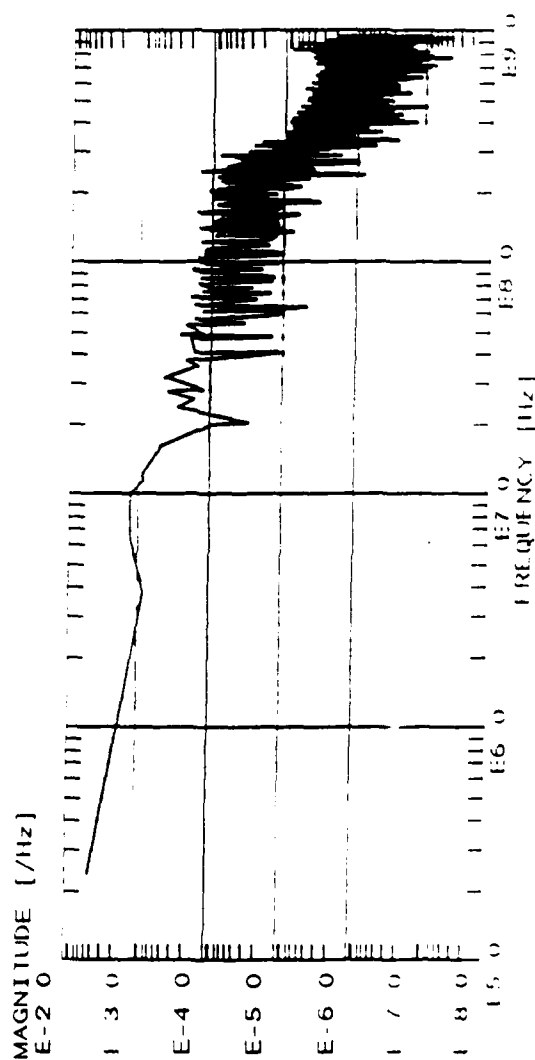
NIST0000 REPEAT 22, CORRECTED DATA

18 DEC 90 15 47 15   TITLE DAY DATA NIST0000 0022 04 1 RAW

AMPLITUDE [V/M]   x 10^-3

Test ID	ARC
Experiment Number	1
Pulse Number	14847
Pulse Date	30-AUG-1990 11 09 51
Quality	6
SIGNAL Peak [V/M]	0 120
Peak Time [sec]	1 013 E 06
Rise Time [sec]	9 540 E 09
Decay Time (1/e) [sec]	1 071 E 06
Signal/Noise Ratio [dB]	34
Probe type	91550 2
Probe Eu Conv factor	0 10000000 E 01 +8
Transmitter Gain [db]	8
Total Scalar Gain [db]	8 00

TIME [sec]   x 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

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DDT00000 REPEAT 36, CORRECTED DATA

18 DEC 90 14:52:56   FILE DAS DATA DD100000 0036 01 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14848
Pulse Date	30-AUG-1990 11.15.19
Quality	4
SIGNAL: Peak [eu]	47.27 E+00
Peak Time [sec]	93.23 E-09
Rise Time [sec]	9.151 E-09
Decay Time (1/e) [sec]	35.54 E-09
Signal/Noise Ratio [dB]	35
Probe type	ACD-4
Probe Eu Conv factor	0.8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [ ] $\times 10^3$

TIME [sec] $\times 10^{-6}$

MAGNITUDE [/Hz]

FREQUENCY [Hz]

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NRL00000 REPEAT 33, CORRECTED DATA

[FILE DIR DATA DATA NRL00000 0033 02 1 RAW]

IR DIR 90 17 17 05
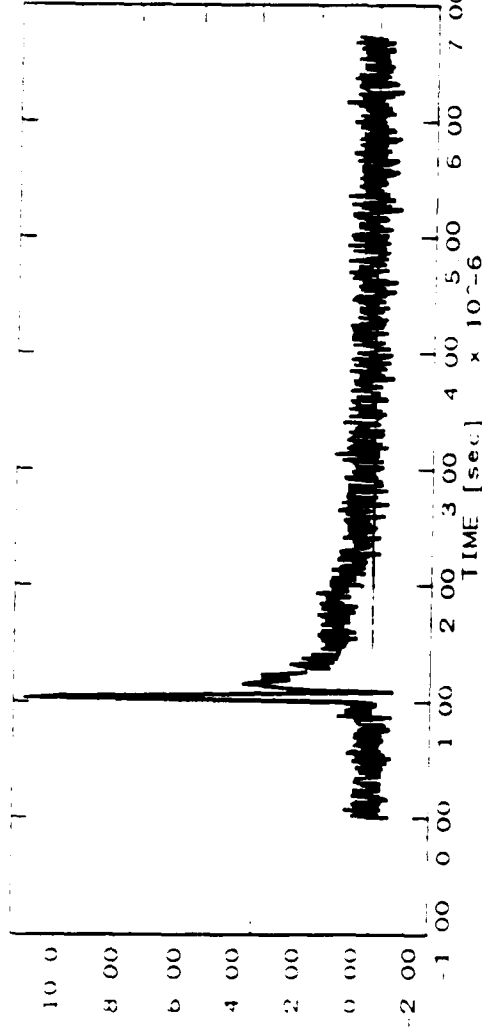
Test ID	ARC
Experiment Number	1
Pulse Number	14848
Pulse Date	30-AUG-1990 11 15 45
Quality	4
SIGNAL Peak [V/M]	11 60 E-03
Peak Time [sec]	1.047 E-06
Rise Time [sec]	11 32 E-09
Decay Time (1/e) [sec]	0.121 E-06
Signal/Noise Ratio [dB]	30
Probe type	91550 2
Probe Eu Conv Factor	0.10000000 E01
Transmitter Gain [db]	128
Total Scalar Gain [db]	28

AMPLITUDE [V/M] × 10^-3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-26

NIST0000 REPEAT 23, CORRECTED DATA

18 DEC 90 15 30 23   FILE DAS DATA NIST0000 0023 04 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14848
Pulse Date	30-AUG 1990 11 14 40
Quality	4
SIGNAL Peak [V/M]	0 144
Peak Time [sec]	0 811 E-06
Rise Time [sec]	8 368 E-09
Decay Time (1/e) [sec]	35 67 E-09
Signal/Noise Ratio [dB]	36
Probe type	91550-2
Probe Eu Conv factor	0.1000000E+01
Transmitter Gain [db]	18
Total Scalar Gain [db]	8

AMPLITUDE [V/M] x 10^3
TIME [sec] x 10^-6

MAGNITUDE [V/M/Hz]
FREQUENCY [Hz]
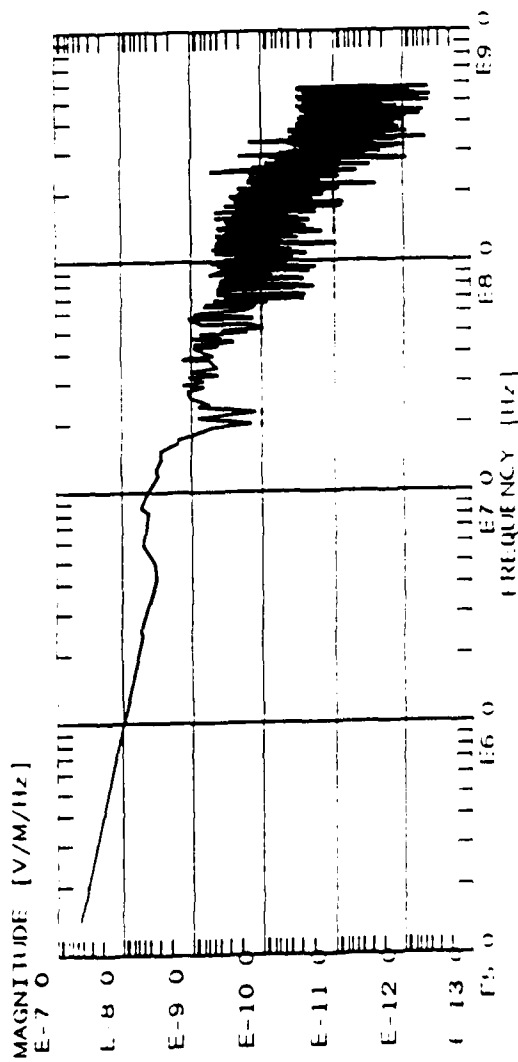
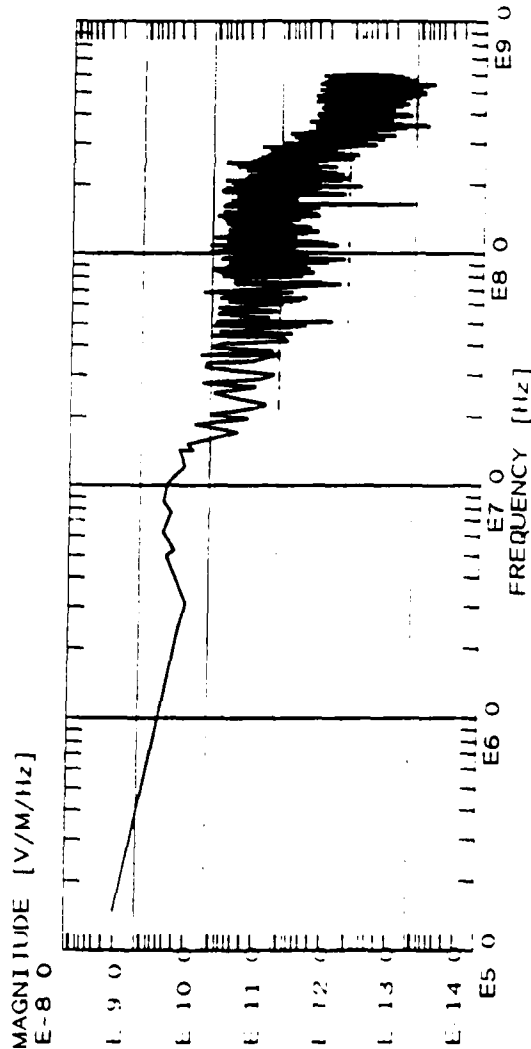Test ID   ARC
Experiment Number   1
Pulse Number   14849
Pulse Date   30-AUG 1990 11 24 14
Quality   6

SIGNAL   Peak [eu]   43 67 E+03
         Peak Time [sec]   90 90 E-09
         Rise Time [sec]   9 226 E-09
         Decay Time (1/e) [sec]   36 90 E-09
         Signal/Noise Ratio [dB]   32

Probe type   ACD-4
Probe Eu Conv factor   0 88540001 11

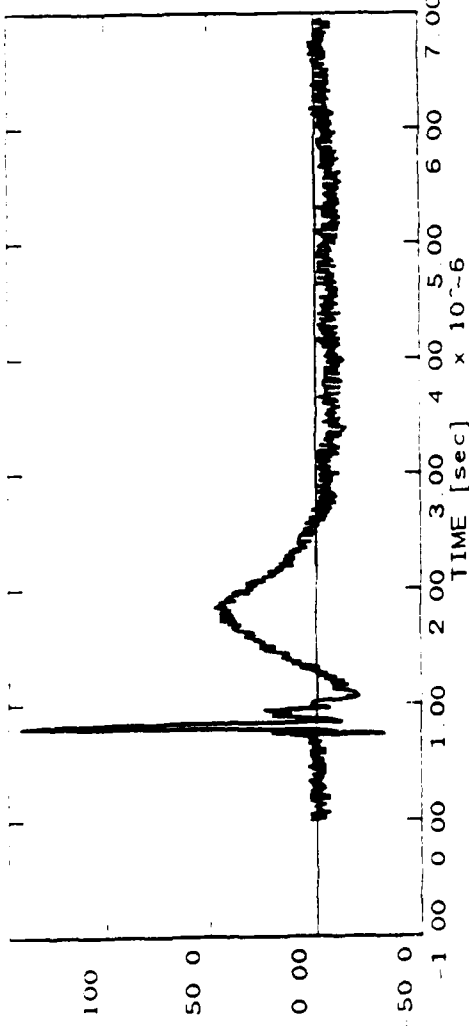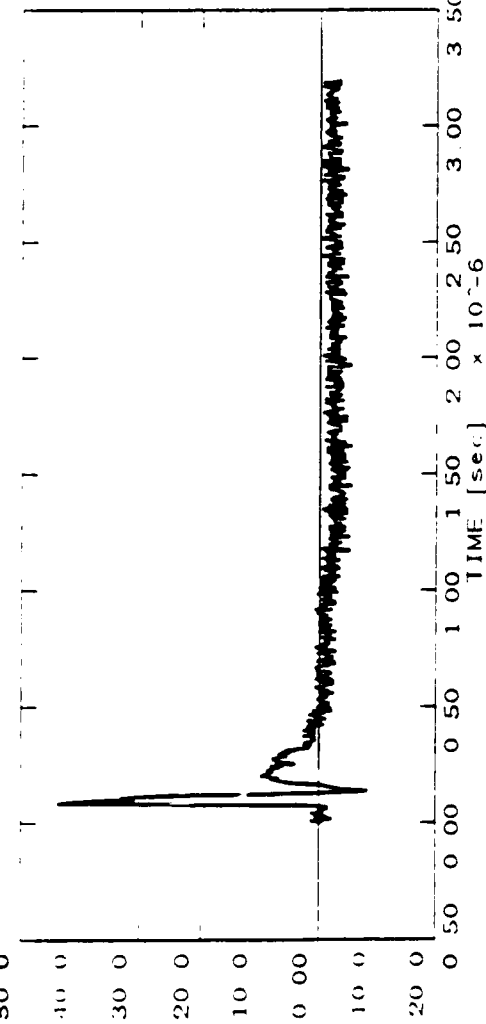Transmitter Gain [db]   11
Total Scalar Gain [db]   -102
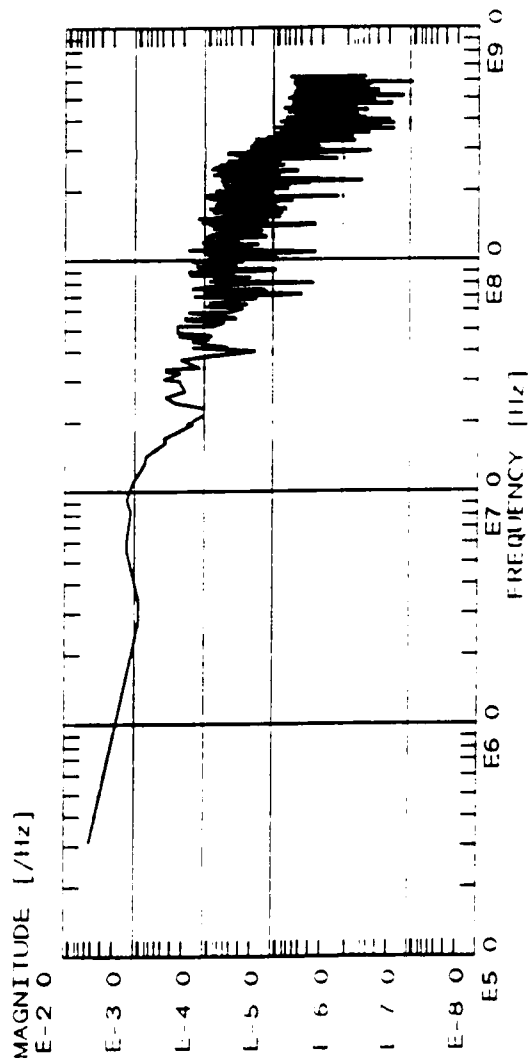
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18-DEC 90 17 18 43   FILE DAS DATA NRL00000 0034 02 1 RAW

AMPLITUDE [V/M]   × 10^-3

Test ID	ARC
Experiment Number	1
Pulse Number	14849
Pulse Date	30-AUG-1990 11:24:28
Quality	6
SIGNAL Peak [V/M]	10 46 E-03
Peak Time [sec]	0 100 E-06
Rise Time [sec]	9 887 E-09
Decay Time (1/e) [sec]	24 21 E-09
Signal/Noise Ratio [dB]	29
Probe type	91550-2
Probe Eu Conv factor	0 1000000E+01
Transmitter Gain [db]	128
Total Scalar Gain [db]	28

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]
E-9.0

FREQUENCY [Hz]

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NIST0000 REPEAT 24, CORRECTED DATA

TITLE DAG DATA NIST0000 0024 04 1 RAW

18 DEC 90 15 53 21
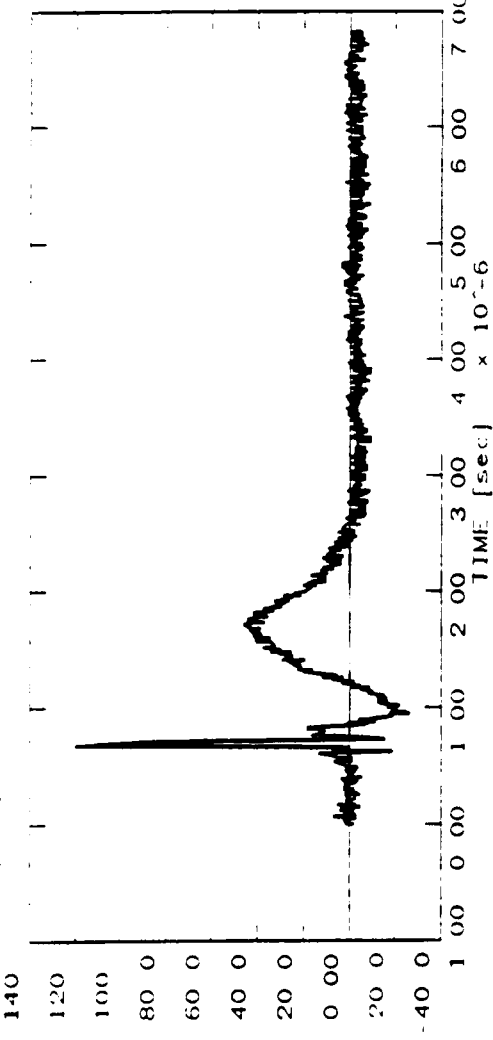
Test ID	ARC
Experiment Number	1
Pulse Number	14849
Pulse Date	30-AUG-1990 11 23 59
Quality	6
SIGNAL Peak [V/M]	0 120
Peak Time [sec]	0 690 E 06
Rise Time [sec]	8 159 E-09
Decay Time (1/e) [sec]	1 028 E-06
Signal/Noise Ratio [dB]	33
Probe type	91550-2
Probe Eu Conv Factor	0 1000000E+01
Transmitter Gain [db]	+8
Total Scalar Gain [db]	8

AMPLITUDE [V/M] × 10 3
140
120
100
80 0
60 0
40 0
20 0
0 00
20 0
-40 0
1 00 0 00 1 00 2 00 3 00 4 00 5 00 6 00 7 00
TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]
E-7 0
E 8 0
E 9 0
L 10 0
E-11 0
E-12 0
E-13 0
E5 0 E6 0 E7 0 E8 0 E9 0
FREQUENCY [Hz]

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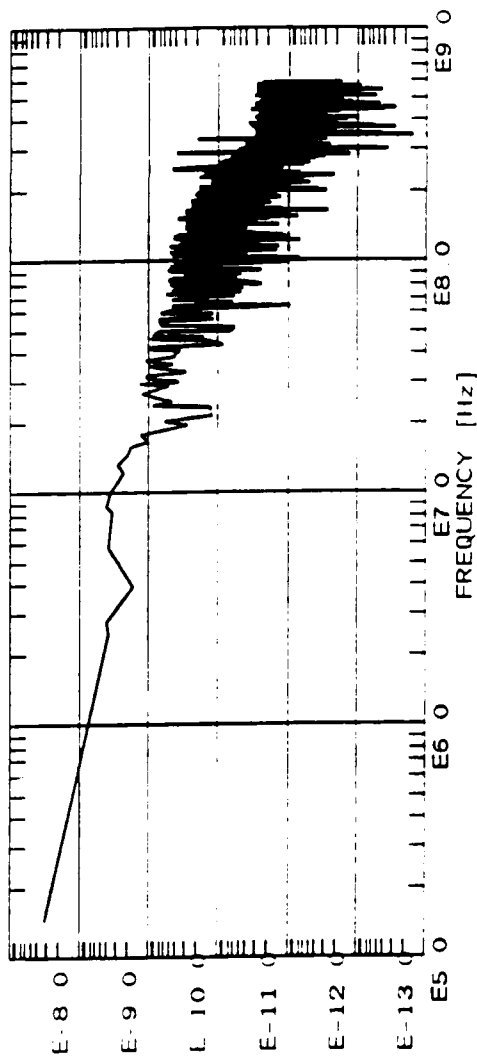
DDT00000 REPEAT 38, CORRECTED DATA

18 DEC-90 14 36 53

FILE DAS DATA DDT00000 0038 01 1 RAW
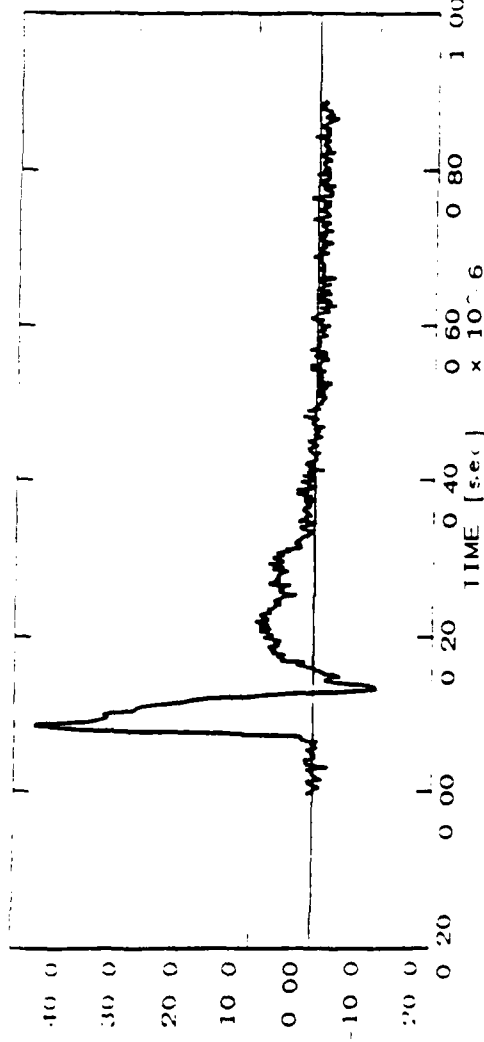
Test ID .... ARC
Experiment Number 1
Pulse Number 14850
Pulse Date 30-AUG 1990 11 27 34
Quality 4
SIGNAL Peak [eu] .... 46 57 E+03
        Peak Time [sec] 86 22 E-09
        Rise Time [sec] 8 666 E-09
        Decay Time (1/e) [sec] 35 20 E-09
        Signal/Noise Ratio [dB] 8

Probe type ACD-4
Probe Eu Conv factor 0 8854000E-11
Transmitter Gain [db] 11
Total Scalar Gain [db] .... -102

AMPLITUDE
50 0
40 0
30 0
20 0
10 0
0 00
-10 0
-20 0

× 10^3

0 00   0 20   0 40   0 60   0 80   1 00
TIME [sec]   × 10^-6

MAGNITUDE [/Hz]
E-2 0
E-3 0
E-4 0
E-5 0
E-6 0
E-7 0

E7 0   E8 0   E9 0
FREQUENCY [Hz]

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D-31
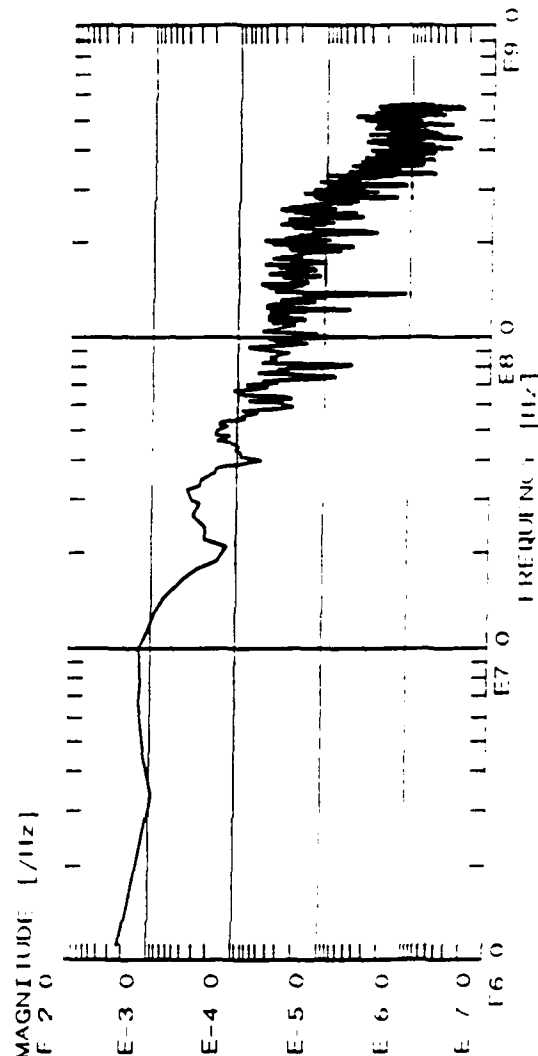
NRLOOOCO REPEAT 35, CORRECTED DATA

TITLE: DATA DATA NRL00000 0035-02-1 RAW
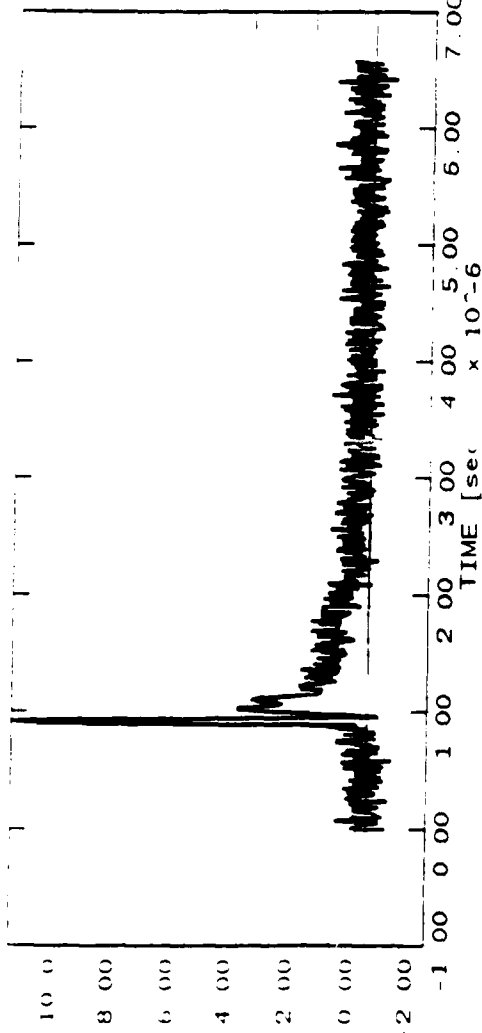
Test ID	ARC
Experiment Number	1
Pulse Number	1-1850
Pulse Date	30-AUG 1990 11:27:48
Quality	4
SIGNAL Peak [V/M]	11.90 E-03
Peak Time [sec]	0.918 E-06
Rise Time [sec]	11.42 E-09
Decay Time (1/e) [sec]	24.75 E-09
Signal/Noise Ratio [dB]	30
Probe type	91550-2
Probe Eu Conv factor	0.1000000E+01
Transmitter Gain [db]	28
Total Scalar Gain [db]	28
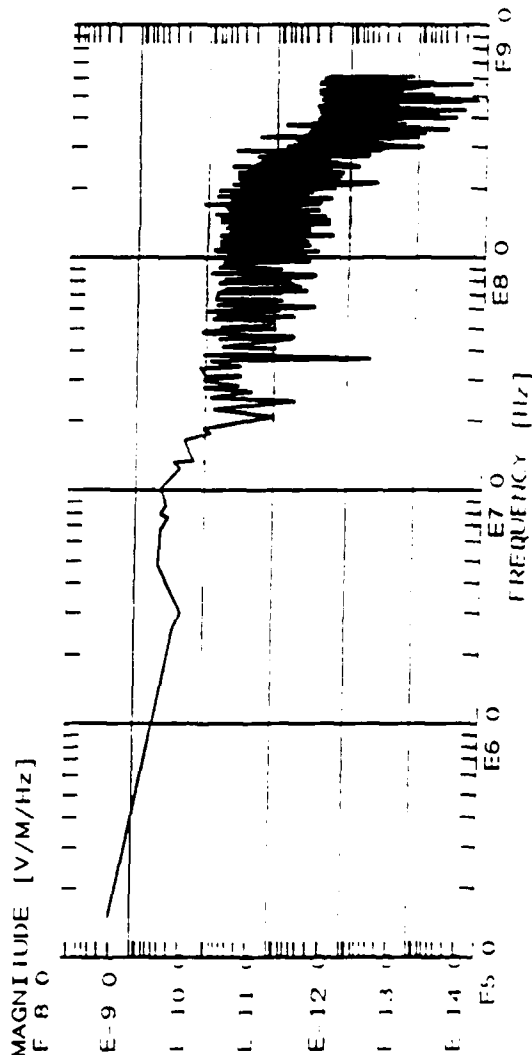
FOR OFFICIAL USE ONLY

NIST0000 REPEAT 25, CORRECTED DATA

18 DEC 90 15 56 21   FILE DAS DATA NIST0000 0025 04 1 RAW
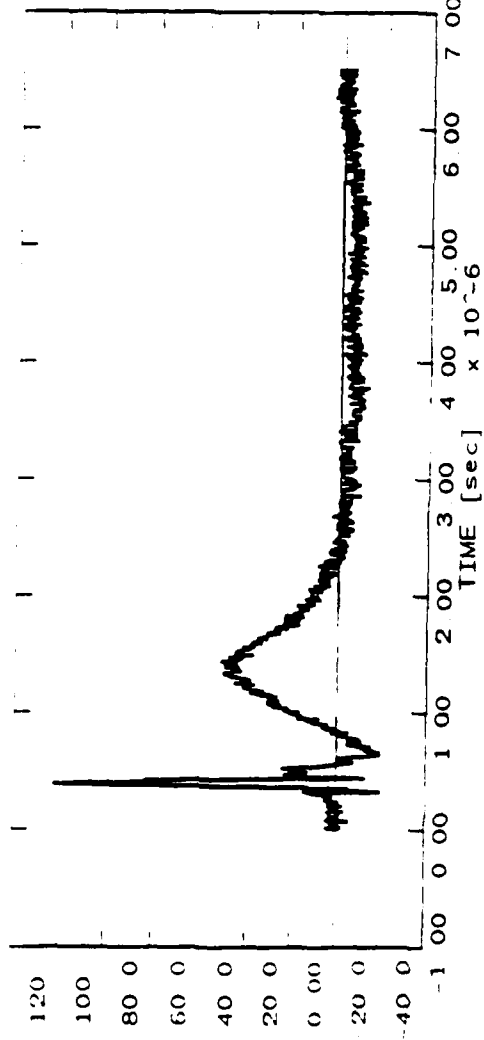
Test ID	ARC
Experiment Number	1
Pulse Number	14850
Pulse Date	30-AUG-1990 11 27 14
Quality	4
SIGNAL: Peak [V/M]	0 123
Peak Time [sec]	0 394 E-06
Rise Time [sec]	*9 102 E-09*
Decay Time (1/e) [sec]	1 130 E-06
Signal/Noise Ratio [dB]	34
Probe type	91550-2
Probe Eu Conv factor	0 1000000E+01
Transmitter Gain [db]	18
Total Scalar Gain [db]	8

AMPLITUDE [V/M] × 10^-3
TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]
FREQUENCY [Hz]

D-33
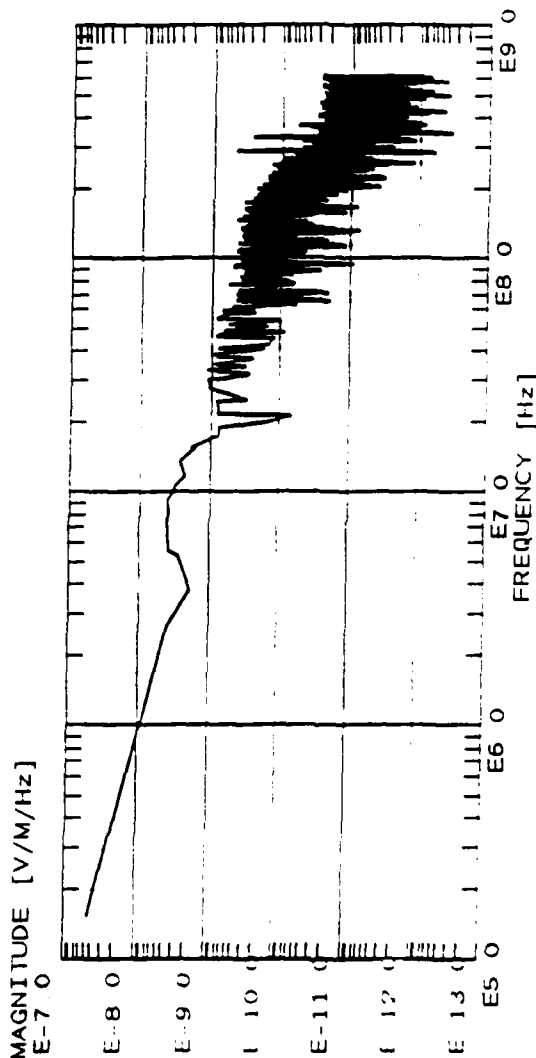
DDTO0000 REPEAT 39, CORRECTED DATA

18 DEC 90 14:38:45   TITLE DAG DATA DDTO0000 0039 01 1 RAW

AMPLITUDE [ ]   × 10^3
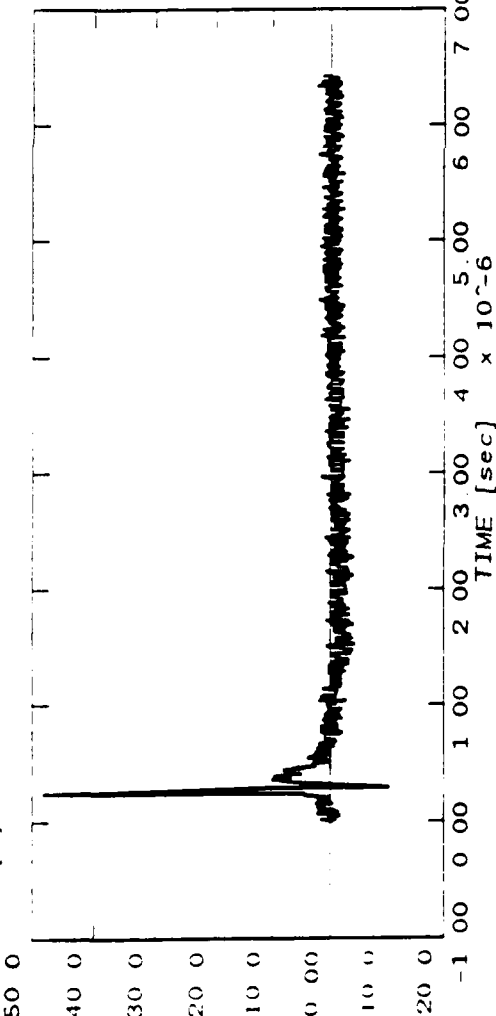
Test ID	ARC
Experiment Number	1
Pulse Number	14851
Pulse Date	30-AUG-1990 11:31:49
Quality	4
SIGNAL Peak [eu]	48.13 E+03
Peak Time [sec]	0.246 E-06
Rise Time [sec]	9.611 E-09
Decay Time (1/e) [sec]	36.02 E-09
Signal/Noise Ratio [dB]	33
Probe type	ACD 4
Probe Fu Conv Factor	0.885-00001 11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

TIME [sec]   × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

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D-34
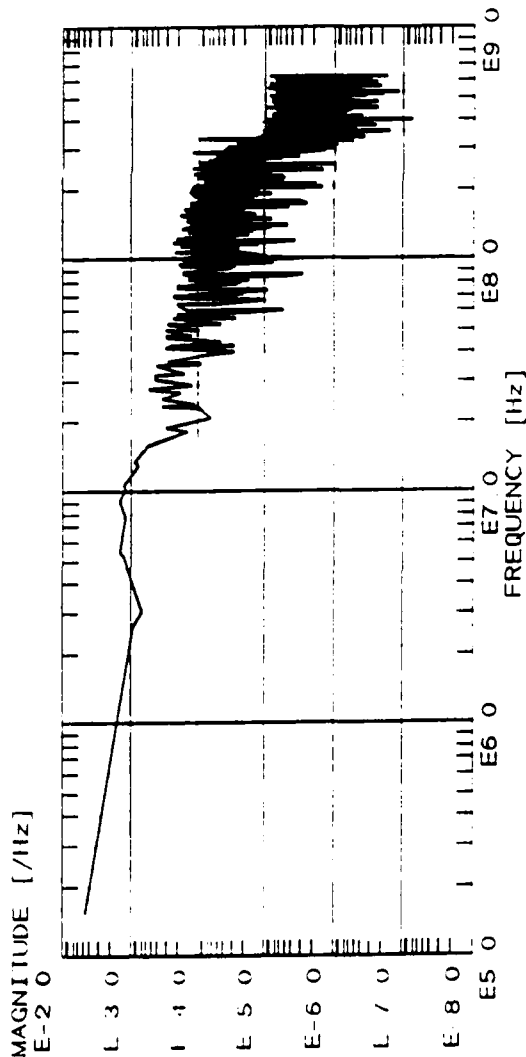
NRLOOOOO REPEAT 36, CORRECTED DATA

18 DEC 90 17:22:04   FILE DAS DATA NRLOOOOO 0036 02 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14851
Pulse Date	30-AUG 1990 11:32:09
Quality	4
SIGNAL: Peak [V/M]	11.22 E-03
Peak Time [sec]	0.141 E-06
Rise Time [sec]	9.764 E-09
Decay Time (1/e) [sec]	25.92 E-09
Signal/Noise Ratio [dB]	32
Probe type	91550-2
Probe Eu Conv factor	0.1000000E+01
Transmitter Gain [db]	,28
Total Scalar Gain [db]	28

FOR OFFICIAL USE ONLY

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NIS10000 REPEAT 26, CORRECTED DATA

FILE DAS DATA NIS10000 00026 04 1 RAW

AMPLITUDE [V/M] × 10^3
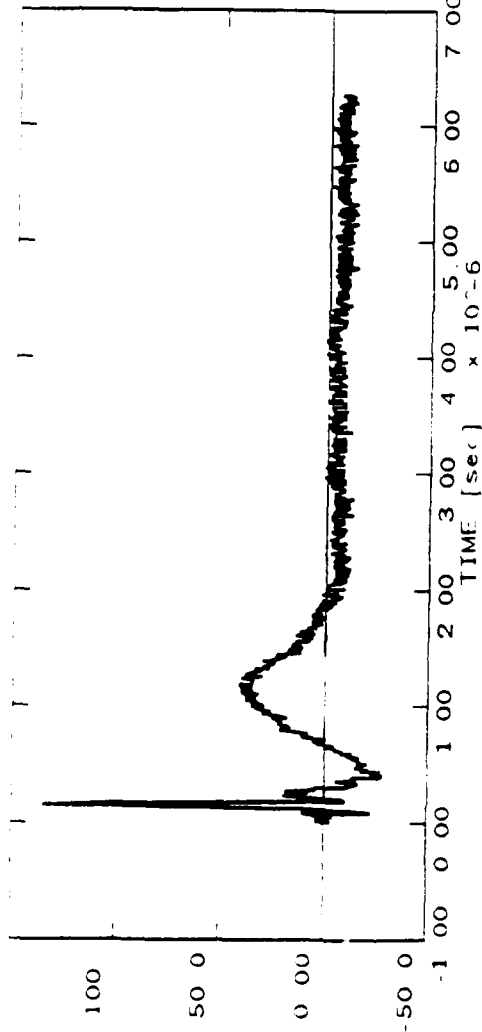
Test ID	ARC
Experiment Number	1
Pulse Number	14851
Pulse Date	30-AUG 1990 11 31 20
Quality	4
SIGNAL: Peak [V/M]	0 134
Peak Time [sec]	0 148 E 06
Rise Time [sec]	8.790 E-09
Decay Time (1/e) [sec]	37 13 E-09
Signal/Noise Ratio [dB]	34
Probe type	91550-2
Probe Eu Conv factor	0 10000000E 01
Transmitter Gain [db]	+8
Total Scalar Gain [db]	8

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

D-36
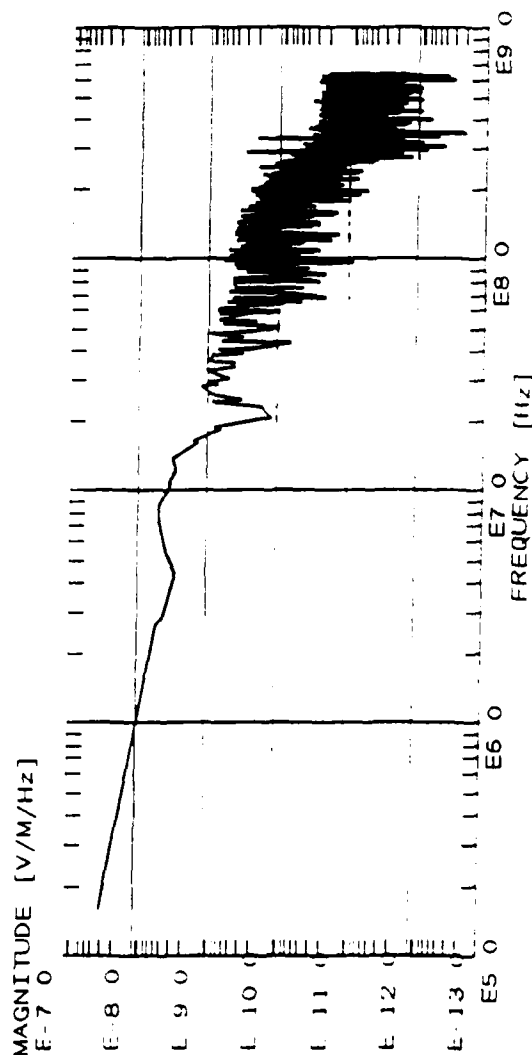
DDT00000 REPEAT 40, CORRECTED DATA

18 DEC 90 14 40 28   FILE DAS DATA DD100000 0040 01 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14852
Pulse Date	30-AUG-1990 11 35 59
Quality	6
SIGNAL Peak [eu]	43 47 E+03
Peak Time [sec]	93 05 E-09
Rise Time [sec]	9 046 E-09
Decay Time (1/e) [sec]	36 47 E-09
Signal/Noise Ratio [dB]	34
Probe type	ACD-4
Probe Eu Conv factor	0 8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [ ]   × 10^3

TIME [sec]   × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

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NRL00000 REPEAT 37, CORRECTED DATA

Test ID	ARC
Experiment Number	1
Pulse Number	14852
Pulse Date	30-AUG-1990 11 36 18
Quality	6

SIGNAL		
Peak [V/M]	11 09	E-03
Peak Time [sec]	1 593	E-06
Rise Time [sec]	10 52	E 09
Decay Time (1/e) [sec]	0 133	E 06
Signal/Noise Ratio [dB]	31	

Probe type	9,550-2
Probe Eu Conv factor	0 10000001 101
Transmitter Gain [db]	28
Total Scalar Gain [db]	28

NIS10000 REPEAT 27, CORRECTED DATA

Test ID	ARC
Experiment Number	1
Pulse Number	14852
Pulse Date	30-AUG-1990 11 35 39
Quality	6
SIGNAL Peak [V/M]	0 140
Peak Time [sec]	0 171 E-06
Rise Time [sec]	8 623 E-09
Decay Time (1/e) [sec]	37 60 E-09
Signal/Noise Ratio [dB]	34
Probe type	91550 2
Probe Eu Conv factor	0 10000000.01
Transmitter Gain [db]	18
Total Scalar Gain [db]	8

AMPLITUDE [V/M] × 10^3

TIME [sec] × 10^-6
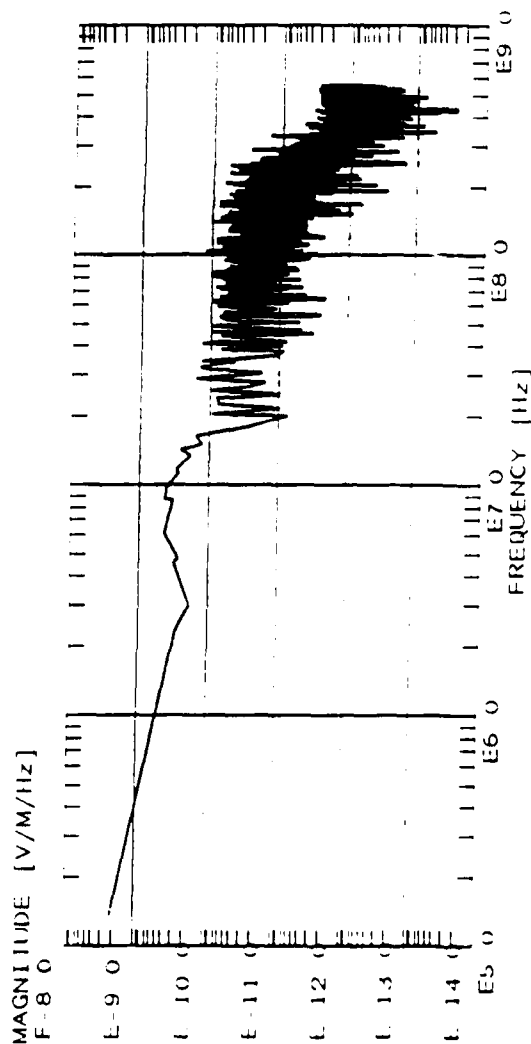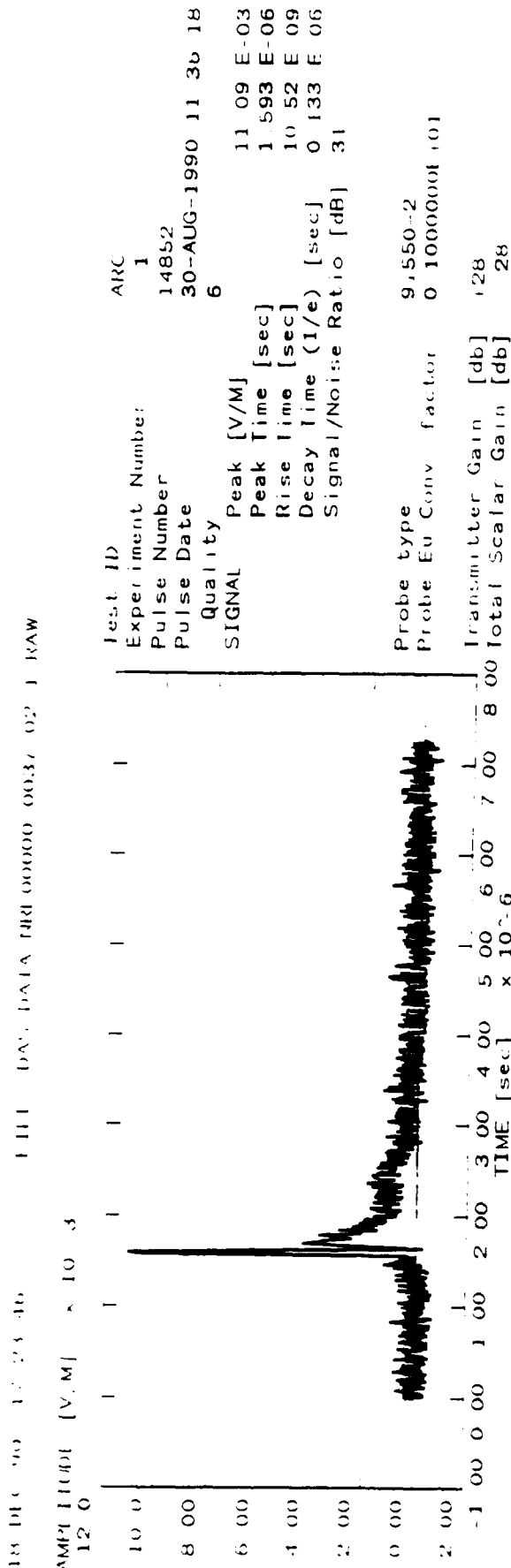
MAGNITUDE [V/M/Hz]
E-7 0

FREQUENCY [Hz]

DDT00000 REPEAT 42, CORRECTED DATA

18 DEC 90   14 43 59   FILE   DAS DATA DDT00000 0042 01 1 RAW
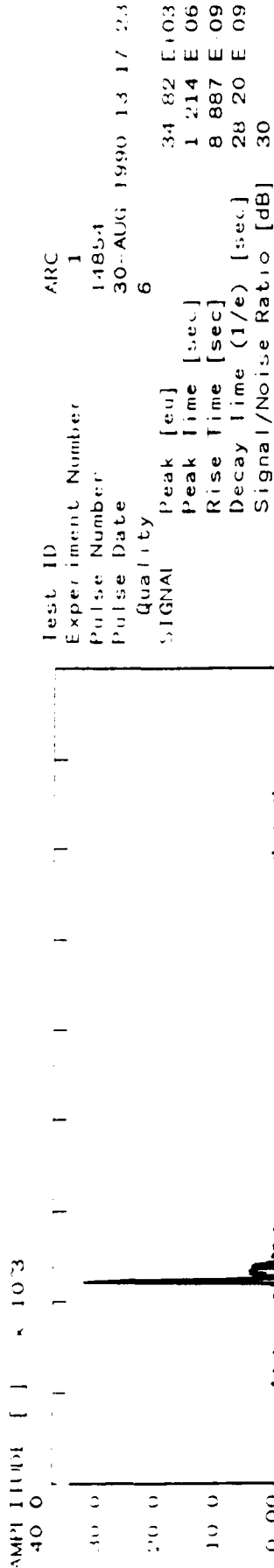
Test ID	ARC
Experiment Number	1
Pulse Number	1485-1
Pulse Date	30-AUG 1990 13 17 23
Quality	6
SIGNAL Peak [eu]	34 82 E 03
Peak Time [sec]	1 214 E 06
Rise Time [sec]	8 887 E 09
Decay Time (1/e) [sec]	28 20 E 09
Signal/Noise Ratio [dB]	30
Probe type	ACD-4
Probe Eu Conv factor	0 8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [ ] × 10^3

TIME [sec] × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]
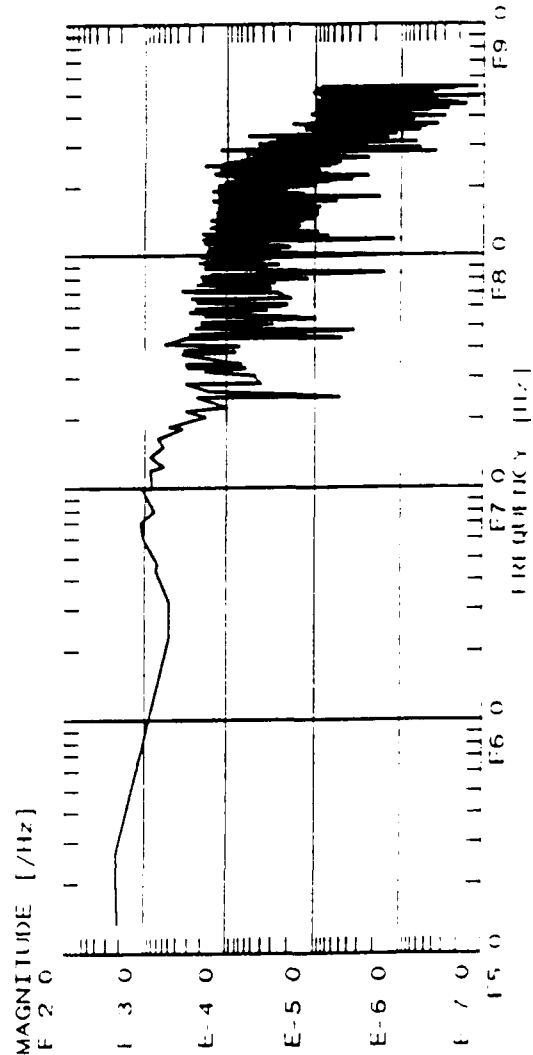
NRL00000 REPEAT 39, CORRECTED DATA

18 DEC 90 17:27:02   FILE DAS DATA NRL00000 0039 02 1 RAW

AMPLITUDE [V/M]   × 10^3

Test ID	ARC
Experiment Number	1
Pulse Number	14854
Pulse Date	30-AUG 1990 13:17:47
Quality	6
SIGNAL Peak [V/M]	8.036 E-03
Peak Time [sec]	99.43 E-09
Rise Time [sec]	19.31 E-09
Decay Time (1/e) [sec]	14.11 E-09
Signal/Noise Ratio [dB]	25
Probe type	91550 2
Probe Eu Conv factor	0.1000000E+01
Transmitter Gain [db]	.28
Total Scalar Gain [db]	28

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]
E-9 0

FREQUENCY [Hz]

NIS10000 REPEAT 29, CORRECTED DATA

TIME DAY DATA NIS10000 0029 04 1 RAW

Test ID	ARC	
Experiment Number	1	
Pulse Number	14854	
Pulse Date	30-AUG-1990 13 18 04	
Quality	6	
SIGNAL Peak [V/M]		77 75 E-03
Peak Time [sec]		0 408 E-06
Rise Time [sec]		6 816 E 09
Decay Time (1/e) [sec]		25 64 E 09
Signal/Noise Ratio [dB]		28
Probe type	91550 2	
Probe Eu Conv Factor	0 10000000 (0)	
Transmitter Gain [db]	+8	
Total Scalar Gain [db]	8	

AMPLITUDE [V/M]   × 10^-3

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-42

DDT00000 REPEAT 43, CORRECTED DATA

FILE DAS DATA DDT00000 0043 01 1 RAW

18 DEC 90 14 45 43 × 10^3

Test ID	ARC
Experiment Number	1
Pulse Number	14855
Pulse Date	30-AUG 1990 13 21 35
Quality	4
SIGNAL Peak [eu]	35 27 E+03
Peak Time [sec]	88 03 E-09
Rise Time [sec]	7 742 E-09
Decay Time (1/e) [sec]	28 21 E-09
Signal/Noise Ratio [dB]	30
Probe type	ACD-4
Probe Eu Conv factor	0 8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [-]

TIME [sec] × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

NRL00000 REPEAT 40, CORRECTED DATA

18 DEC 90 17 28 43   FILE DAS DATA NRL 00000 0040 02 1 RAW
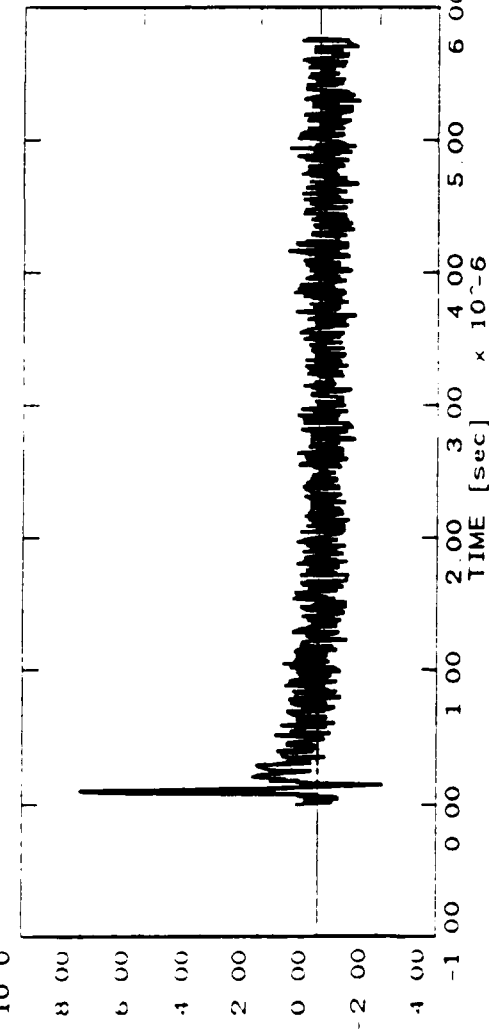
Test ID	ARC
Experiment Number	1
Pulse Number	14855
Pulse Date	30-AUG-1990 13 20 51
Quality	4
SIGNAL	
Peak [V/M]	8 049 E-03
Peak Time [sec]	0 103 E-06
Rise Time [sec]	11 05 E-09
Decay Time (1/e) [sec]	12 83 E-09
Signal/Noise Ratio [dB]	25
Probe type	91550-2
Probe Eu Conv factor	0.1000000E+01
Transmitter Gain [db]	128
Total Scalar Gain [db]	28

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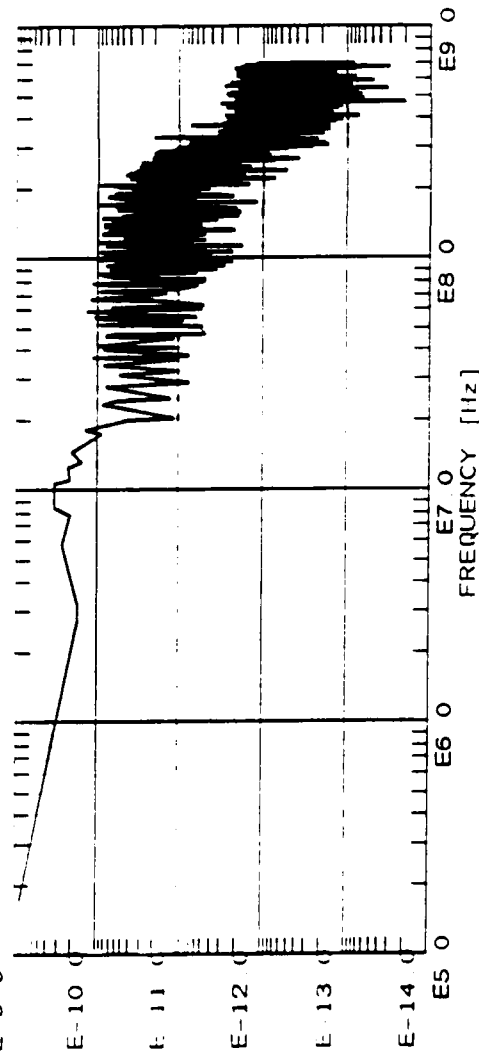
NIST0000 REPEAT 30, CORRECTED DATA

18 DEC 90 16 11 23   FILE DAS DATA NIST0000 0030 04 1 RAW
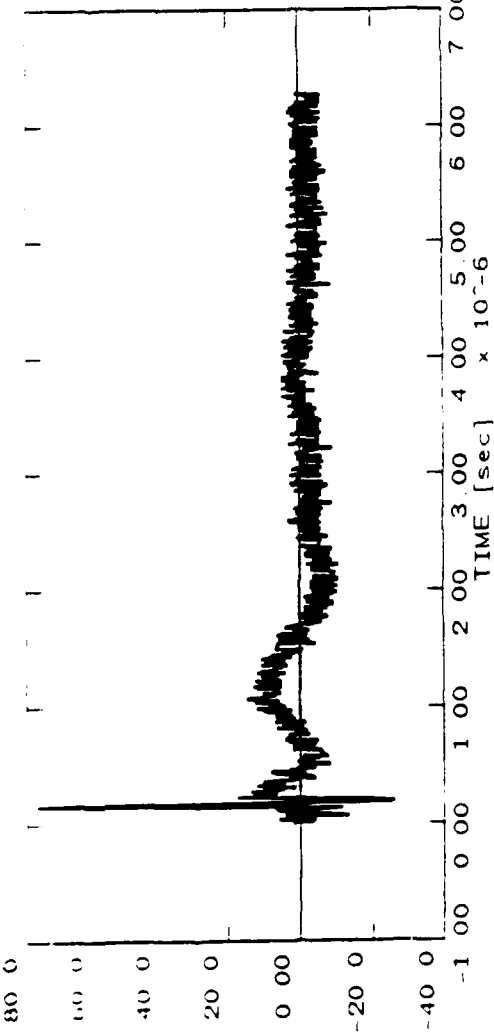
Test ID   ARC
Experiment Number   1
Pulse Number   14855
Pulse Date   30-AUG 1990 13 21 05
Quality   4

SIGNAL Peak [V/M]   76 85 E 03
        Peak Time [sec]   0.151 E-06
        Rise Time [sec]   6.960 E-09
        Decay Time (1/e) [sec]   25.96 E-09
        Signal/Noise Ratio [dB]   25

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

Transmitter Gain [db]   +8
Total Scalar Gain [db]   8

AMPLITUDE [V/M] × 10^ 3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

DDT00000 REPEAT 44, CORRECTED DATA

Test ID .... ARC
Experiment Number 1
Pulse Number 14856
Pulse Date 30-AUG 1990 13 29 54
Quality 4

SIGNAL : Peak [eu] .... 38 84 E+03
         Peak Time [sec] 0.230 E-06
         Rise Time [sec] 8 514 E-09
         Decay Time (1/e) [sec] .. 27 56 E-09
         Signal/Noise Ratio [dB] . 31

Probe type ACD-4
Probe Eu Conv factor 0 88540000E 11

Transmitter Gain [db] .... +11
Total Scalar Gain [db] .... -102

AMPLITUDE [ ] × 10^3

TIME [sec] × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]
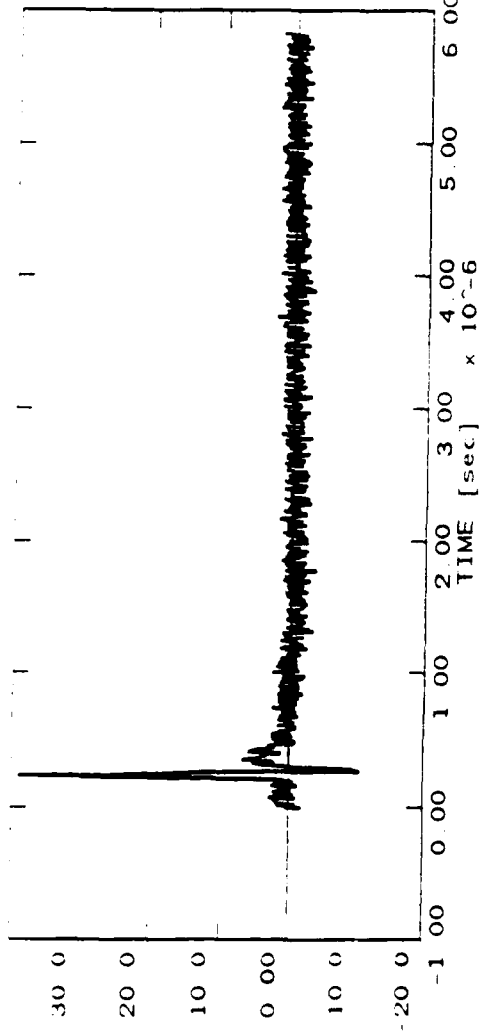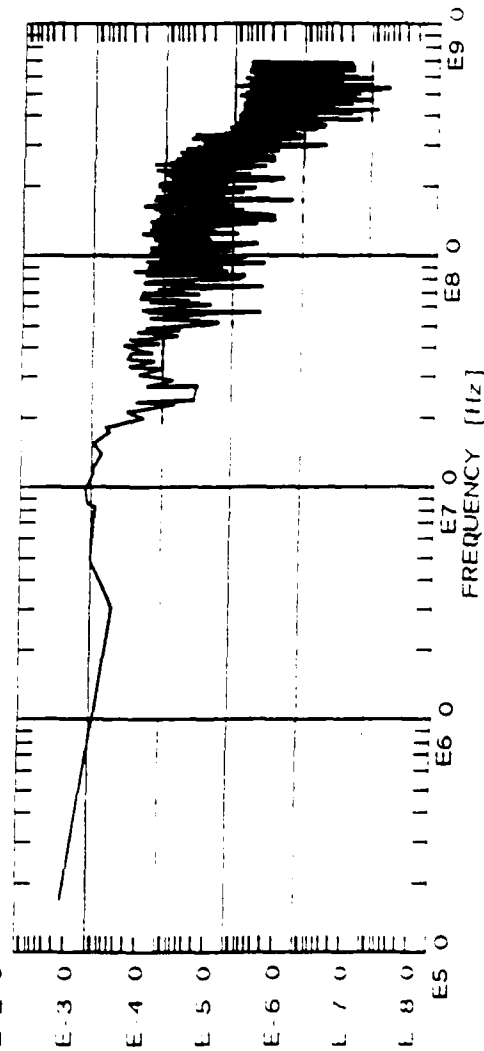
NRL00000 REPEAT 41, CORRECTED DATA

18 DEC 90 17:30:19   TITLE DAS DATA NRL00000 0041 02 1 RAW
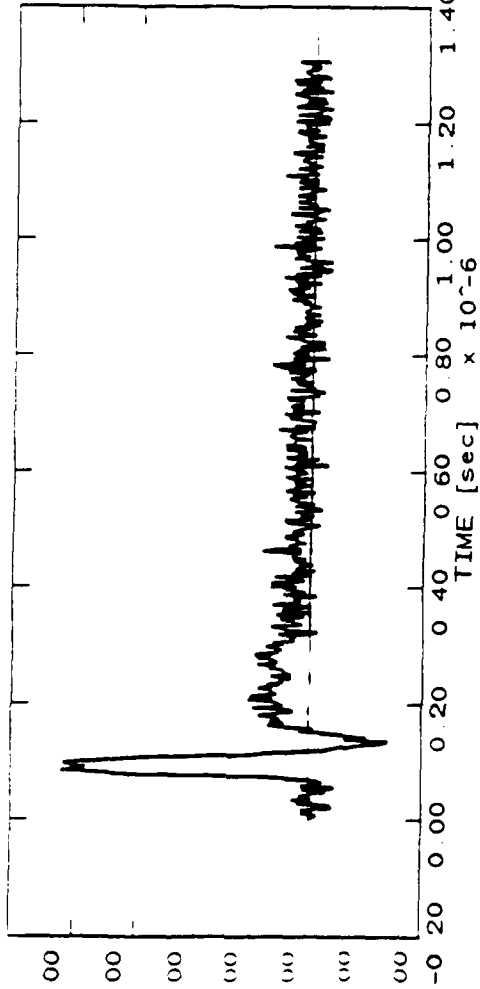
Test ID	ARC
Experiment Number	1
Pulse Number	14856
Pulse Date	30-AUG-1990 13:29:01
Quality	4
SIGNAL: Peak [V/M]	8.366 E-03
Peak Time [sec]	86.42 E-09
Rise Time [sec]	8.670 E-09
Decay Time (1/e) [sec]	26.94 E-09
Signal/Noise Ratio [dB]	26
Probe type	91550.2
Probe Eu Conv factor	0.100000000E+01
Transmitter Gain [db]	128
Total Scalar Gain [db]	28

AMPLITUDE [V/M] × 10^-3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

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NIST0000 REPEAT 31, CORRECTED DATA

18 DEC 90 16 14 07   FILE DAS DATA NIST0000 0031 04 1 RAW

Test ID   ARC
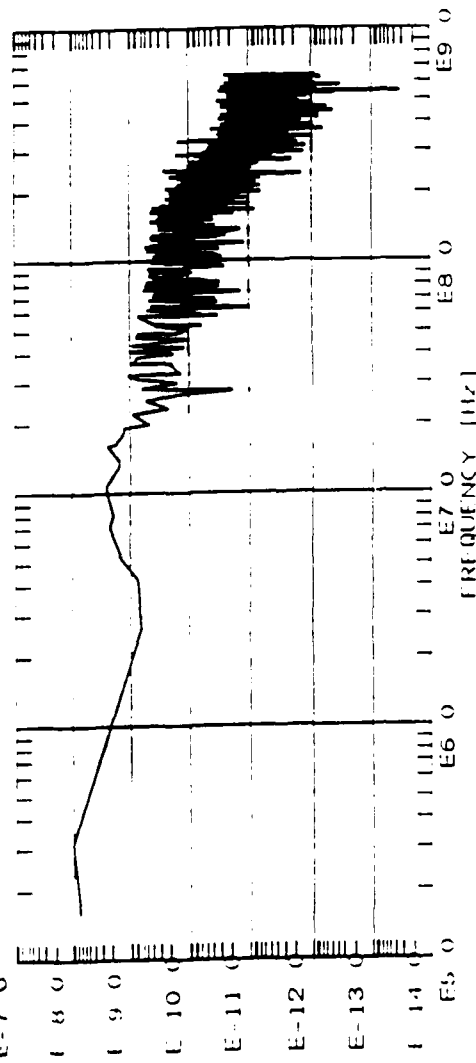Experiment Number   1
Pulse Number   14856
Pulse Date   30-AUG-1990 13.29 27
Quality   4
SIGNAL Peak [V/M]   84 73 E-03
        Peak Time [sec]   0 153 E-06
        Rise Time [sec]   5 903 E-09
        Decay Time (1/e) [sec]   35 06 E-09
        Signal/Noise Ratio [dB] 29

Probe type   91550-2
Probe Eu Conv factor   0.1000000E+01

Transmitter Gain [db]   +8
Total Scalar Gain [db]   8

AMPLITUDE [V/M] × 10^3

100
80 0
60 0
40 0
20 0
0 00
-20 0
-40 0
-60 0

-1 00 0 00 1 00 2 00 3 00 4 00 5 00 6 00 7 00
TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]
E-7 0
1 0
1 0
E 10
E 11
E 12
E 13
E 14
E5 0   E6 0   E7 0   E8 0   E9 0
                    FREQUENCY [Hz]

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D-48
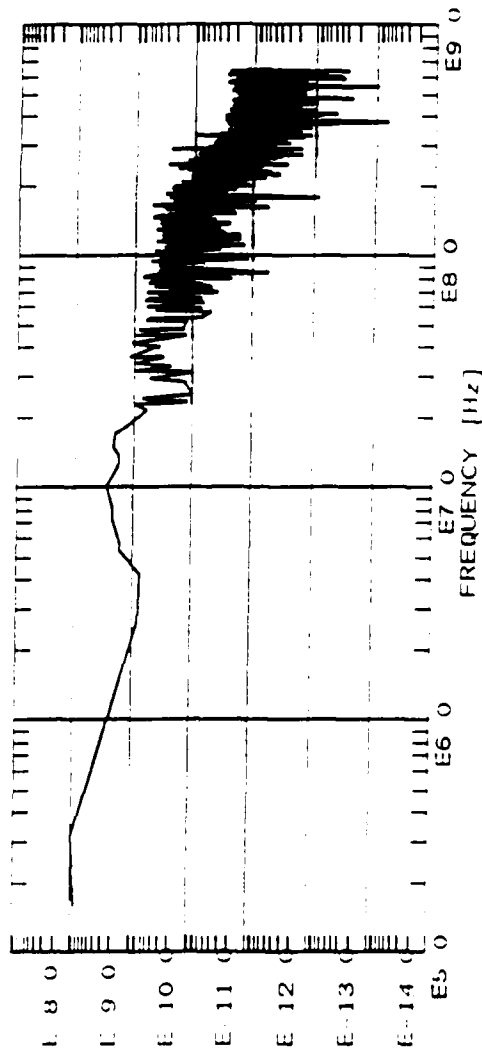
DDTOOOOO REPEAT 45, CORRECTED DATA

AMPLITUDE
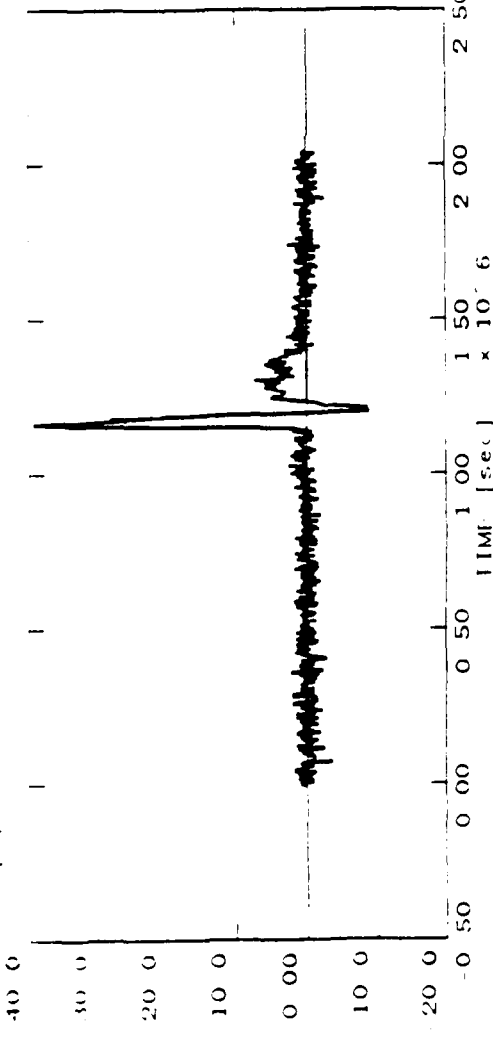
Test ID   ARC
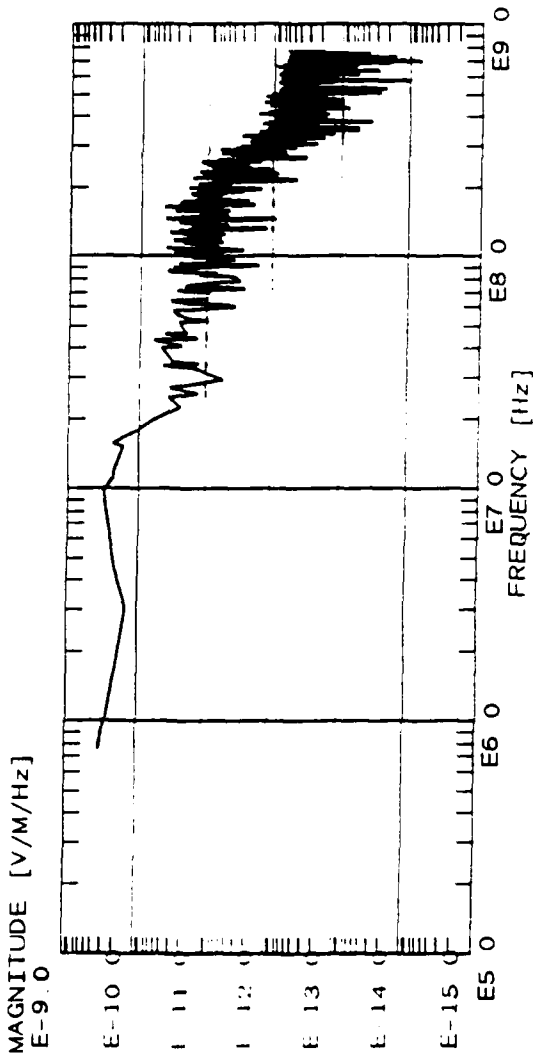Experiment Number   1
Pulse Number   1485/
Pulse Date   30-AUG-1990 13 34 0?
    Quality   4
SIGNAL Peak [eu]   39 24 E+03
        Peak Time [sec]   1 166 E-06
        Rise Time [sec]   8 739 E-09
        Decay Time (1/e) [sec]   27 73 E-09
        Signal/Noise Ratio [dB]   32

Probe type   ACD-4
Probe Eu Conv factor   0 8854000E-11

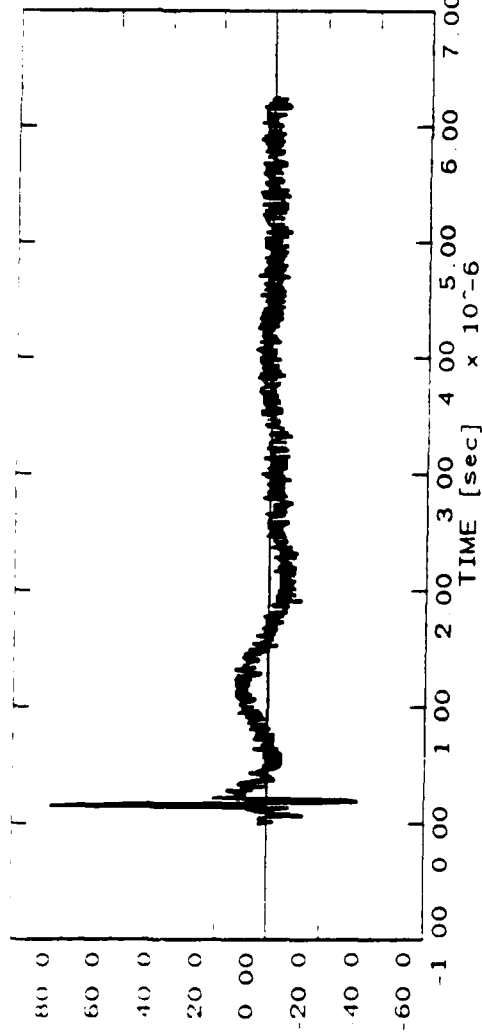Transmitter Gain [db]   +11
Total Scalar Gain [db]   -102

TIME [sec]

MAGNITUDE [/Hz]

FREQUENCY [Hz]

NRLOOOOO REPEAT 42, CORRECTED DATA

18 DEC 90 17:31:59   FILE: DAS DATA NRL OOOOO 0042 02 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14857
Pulse Date	30-AUG-1990 13 34 20
Quality	4
SIGNAL Peak [V/M]	8 279 E-03
Peak Time [sec]	1 576 E-06
Rise Time [sec]	17 58 E-09
Decay Time (1/e) [sec]	11 18 E 09
Signal/Noise Ratio [dB]	24
Probe type	91550-2
Probe Eu Conv factor	0 100000E+01
Transmitter Gain [db]	28
Total Scalar Gain [db]	28

AMPLITUDE [V/M] × 10^-3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-50
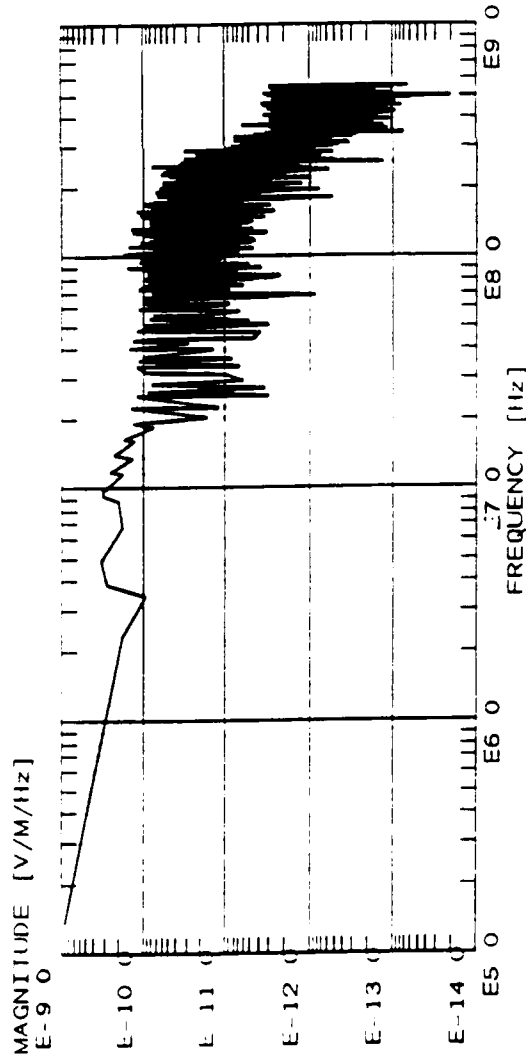
NIST0000 REPEAT 32, CORRECTED DATA

18 DEC 90 16 16 58   FILE DAS DATA NIST0000 0032 04 1 RAW
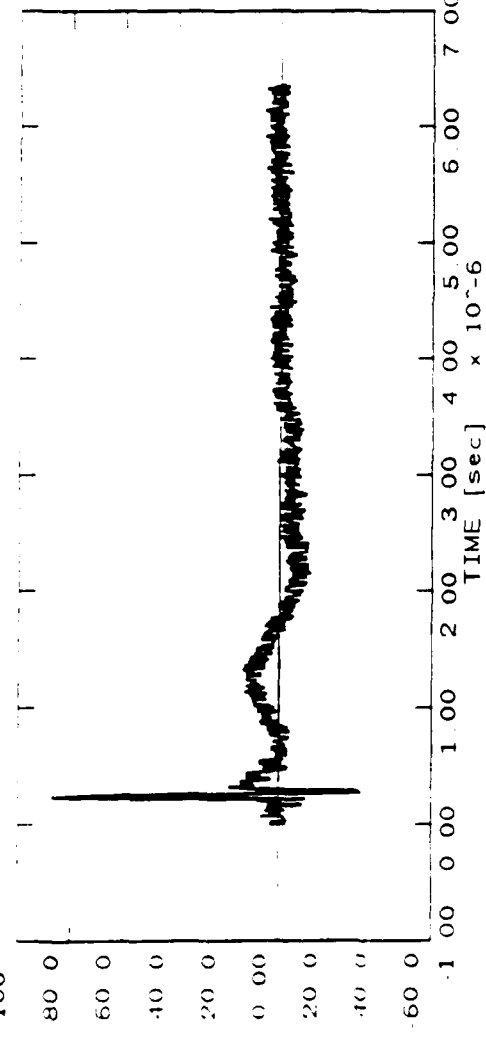
Test ID   ARC
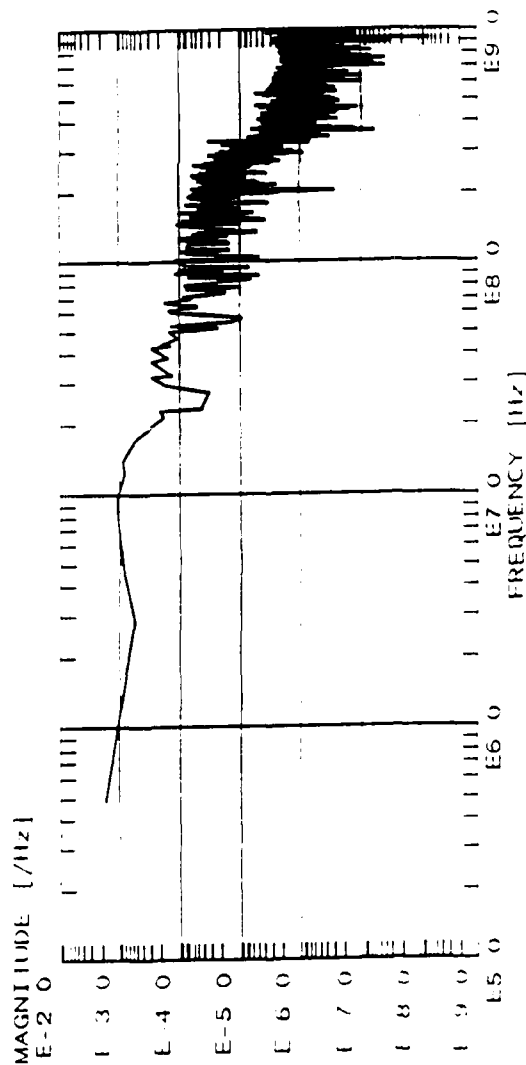Experiment Number   1
Pulse Number   14857
Pulse Date   30-AUG-1990 13 33 34
Quality   4
SIGNAL Peak [V/M]   87 02 E 03
        Peak Time [sec]   0 237 E-06
        Rise Time [sec]   6 435 E-09
        Decay Time (1/e) [sec]   26 16 E 09
        Signal/Noise Ratio [dB]   30

Probe type   91550 2
Probe Eu Conv factor   0 10000000 G1

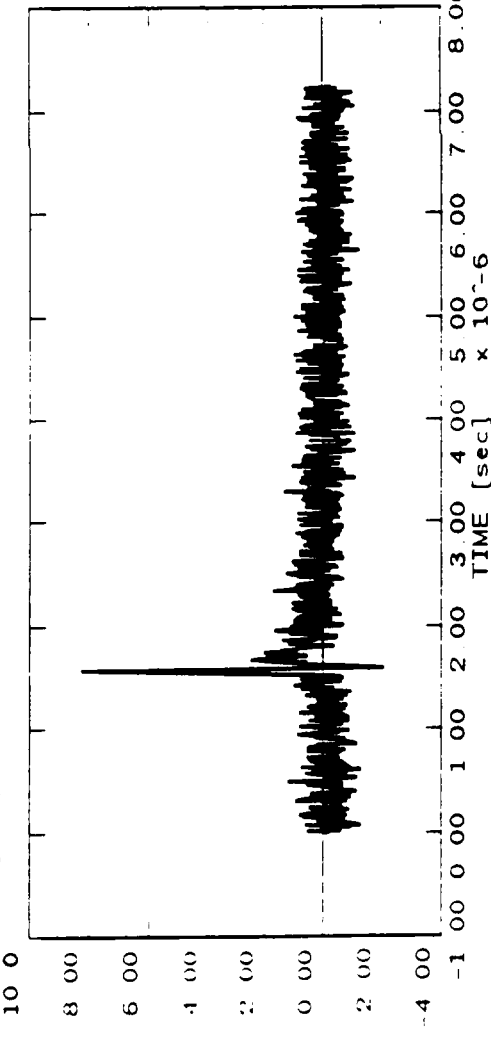Transmitter Gain [db]   +8
Total Scalar Gain [db]   8

AMPLITUDE [V/M] × 10^3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
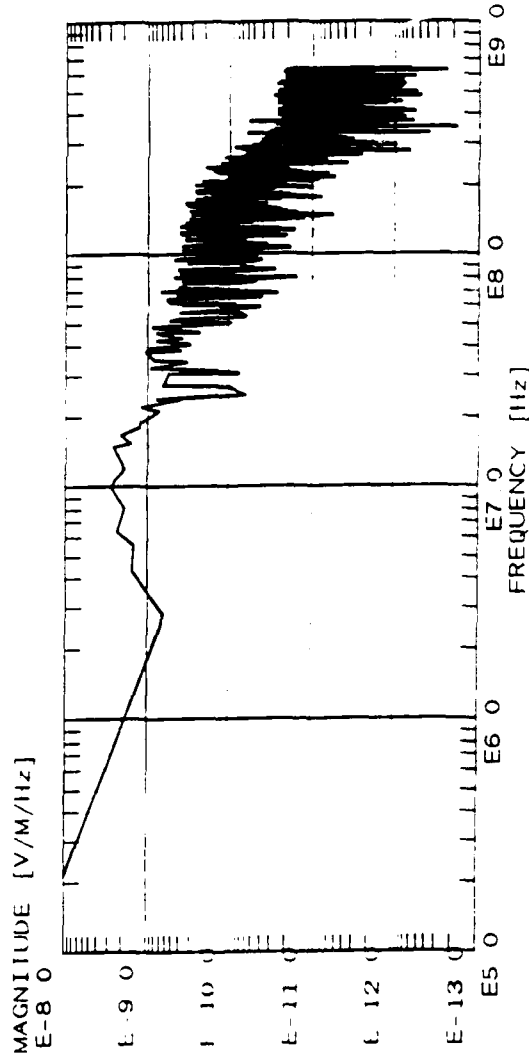
DD100000 REPEAT 46, CORRECTED DATA

FILE DAS DATA DD100000 0046 01 1 RAW

18 DEC 90 14 50 45
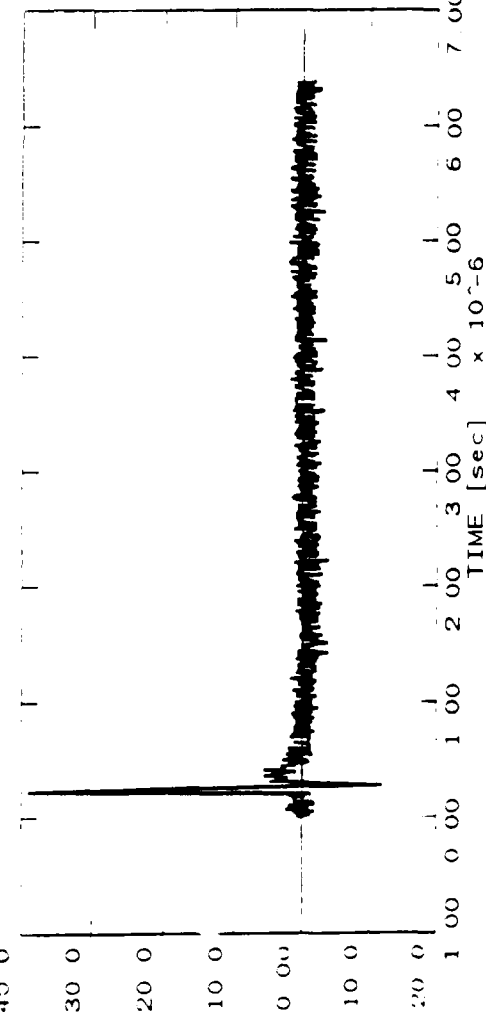
Test ID   ARC
Experiment Number   1
Pulse Number   14858
Pulse Date   30-AUG-1990 13 38:30
Quality   4
SIGNAL   Peak [eu]   38 80 E+03
         Peak Time [sec]   0.231 E-06
         Rise Time [sec]   9 137 E-09
         Decay Time (1/e) [sec]   27.24 E-09
         Signal/Noise Ratio [dB]   32

Probe type   ACD-4
Probe Eu Conv factor   0 8854000E-11
Transmitter Gain [db]   +11
Total Scalar Gain [db]   -102

AMPLITUDE [ ]   × 10^3

TIME [sec]   × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

D-52
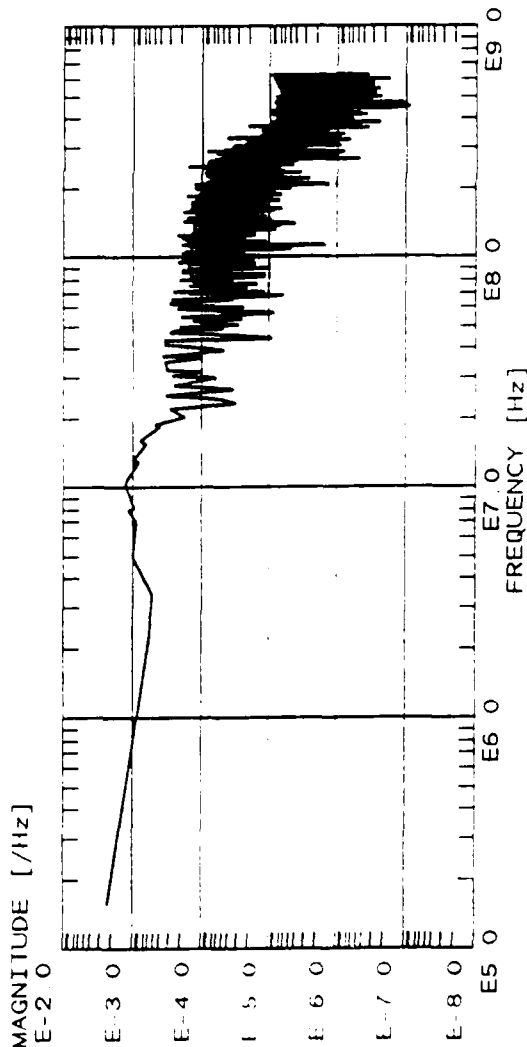
NRL00000 REPEAT 43, CORRECTED DATA

AMPLITUDE [V/M] × 10⁻³
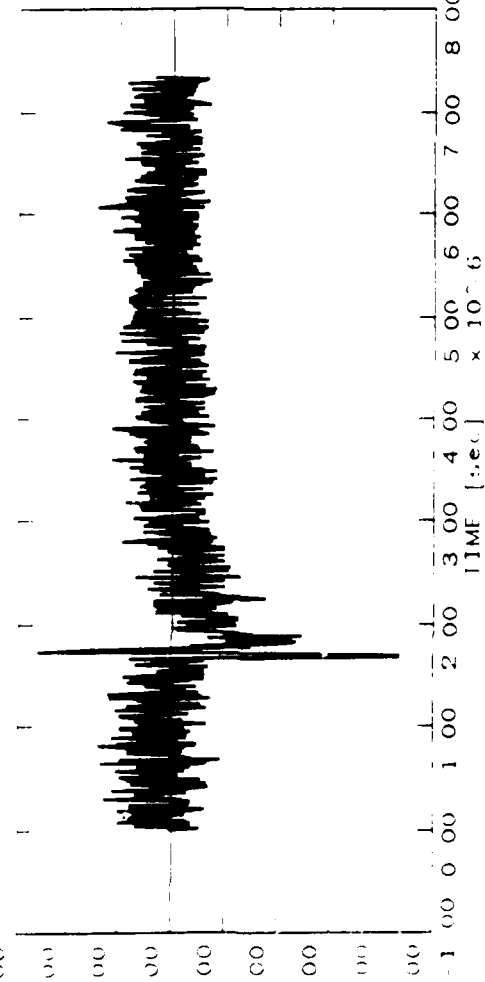
Test ID	ARC
Experiment Number	1
Pulse Number	14858
Pulse Date	30 AUG 1990 13 38 57
Quality	4

SIGNAL

Peak [V/M]	-4 317 E-03
Peak Time [sec]	1 684 E-06
Rise Time [sec]	3 266 E-09
Decay Time (1/e) [sec]	0 562 E-06
Signal/Noise Ratio [dB]	20

Probe type	91550-2
Probe Eu Conv factor	0 1000000E+01
Transmitter Gain [db]	+28
Total Scalar Gain [db]	28

TIME [sec] × 10⁻⁶

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

NIST0000 REPEAT 33, CORRECTED DATA

18 DEC 90   16 19 54   FILE DAS DATA NIST0000 0033 04 1 RAW

Test ID   ARC
Experiment Number   1
Pulse Number   14858
Pulse Date   30 AUG 1990 13 38 10
Quality   4

SIGNAL   Peak [V/M]   -53 30 E-03
          Peak Time [sec]   0 146 E-06
          Rise Time [sec]   10 39 E-09
          Decay Time (1/e) [sec] 59 99 E-09
          Signal/Noise Ratio [dB] 24

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

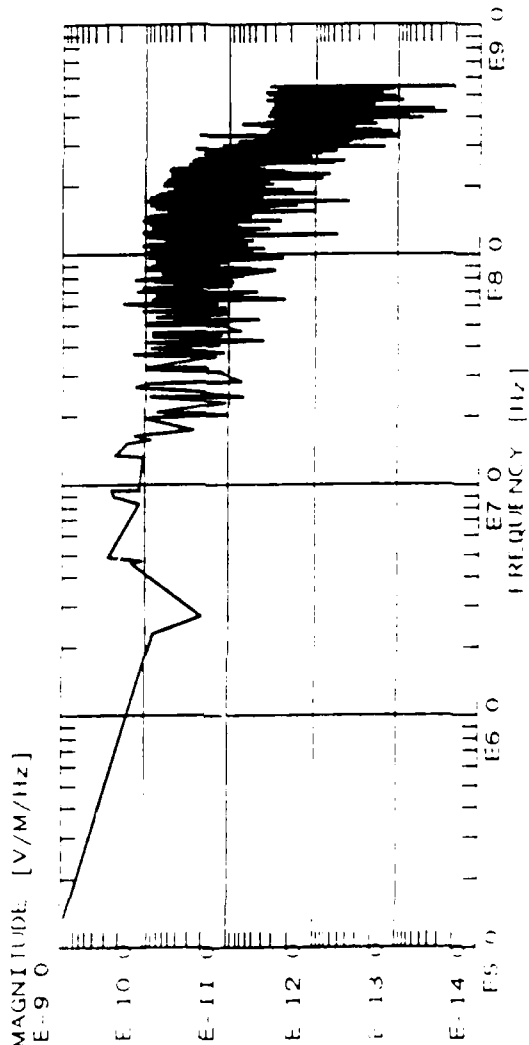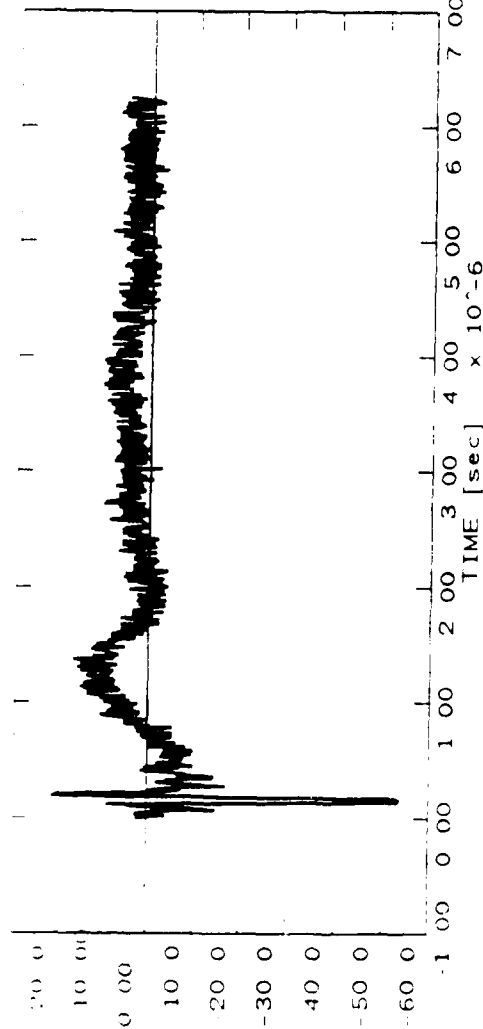Transmitter Gain   [db]   +8
Total Scalar Gain   [db]   8

AMPLITUDE [V/M]   x 10^-3

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

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DDT00000 REPEAT 47, CORRECTED DATA

18 DEC 90 14 52 27   FILE DAS DATA DDT00000 0047 01 1 RAW

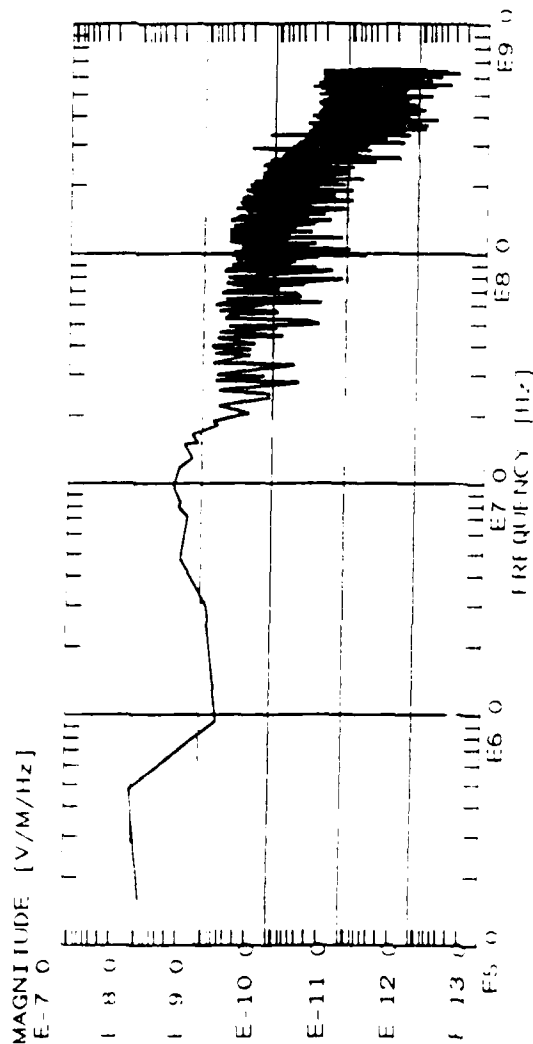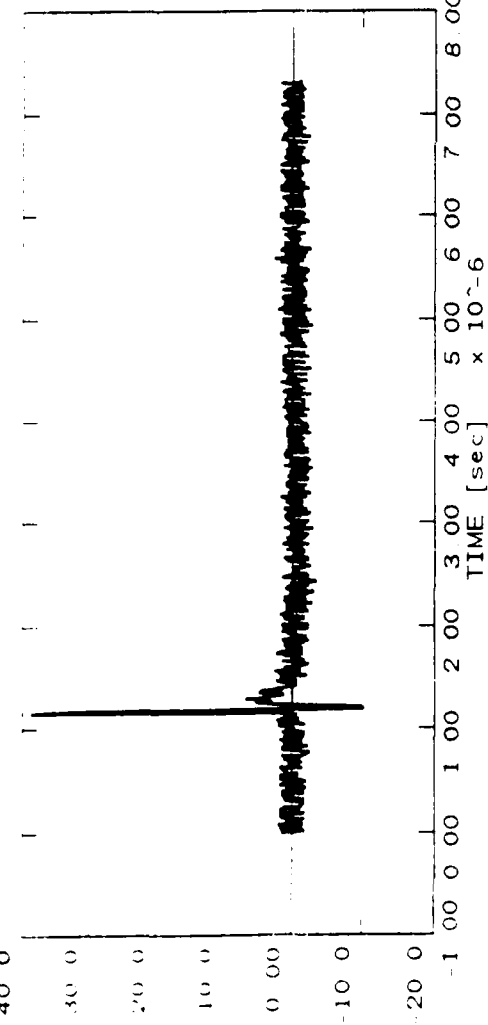Test ID   ARC
Experiment Number   1
Pulse Number   14859
Pulse Date   30-AUG 1990 13 43 38
Quality   4
SIGNAL Peak [eu]   38 64 E+03
        Peak Time [sec]   1 169 E-06
        Rise Time [sec]   8 180 E 09
        Decay Time (1/e) [sec] 27 15 E 09
        Signal/Noise Ratio [dB] 31

Probe type   ACD-4
Probe Eu Conv factor   0 8854000E-11

Transmitter Gain [db]   +11
Total Scalar Gain [db]   -102

AMPLITUDE [ ] × 10^3
40 0
30 0
20 0
10 0
0 00
-10 0
-20 0
     0 00 1 00 2 00 3 00 4 00 5 00 6 00 7 00 8 00
                      TIME [sec] × 10^-6

MAGNITUDE [/Hz]
E 2 0
E 3 0
E 4 0
E 5 0
E-6 0
E-7 0
E-8 0
     E5 0   E6 0   E7 0   E8 0   E9 0
            FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

D-55
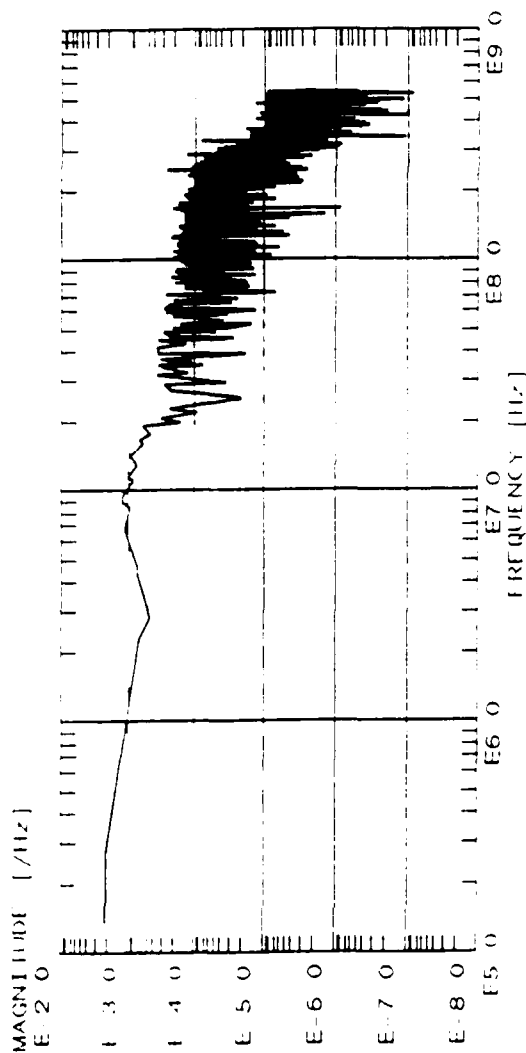
NRI 00000 REPEAT 44, CORRECTED DATA

THE RAW DATA FOR 00000 0044 02 1 RAW
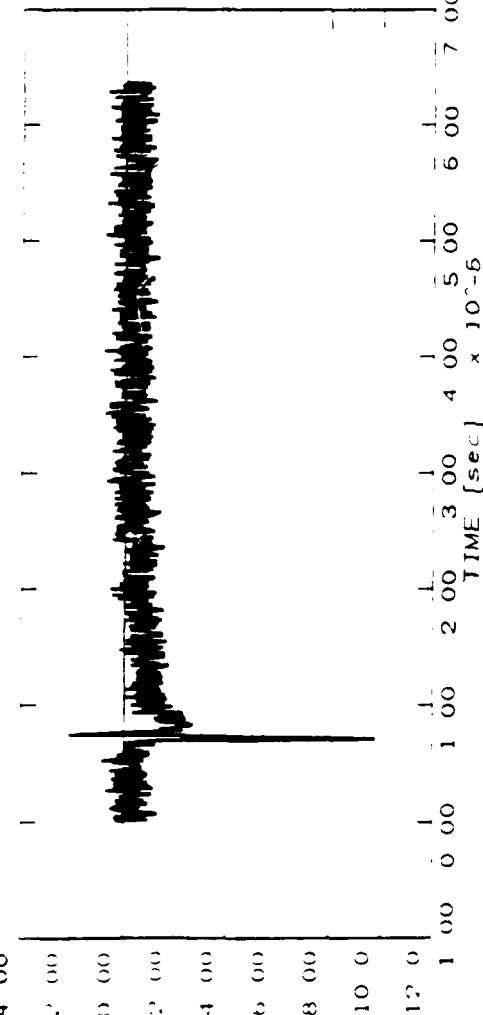
Test ID	ARC	
Experiment Number	1	
Pulse Number	14859	
Pulse Date	30-AUG 1990 13 44 00	
Quality	4	
SIGNAL Peak [V/M]		9 714 E 03
Peak Time [sec]		0 724 E 06
Rise Time [sec]		19 47 E 09
Decay Time (1/e) [sec]		11 69 E 09
Signal/Noise Ratio [dB]		26
Probe type	91550-2	
Probe Eu Conv factor	0.1000000E+01	
Transmitter Gain [db]	128	
Total Scalar Gain [db]	28	

AMPLITUDE [V/M] x 10^3

TIME [sec] x 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

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NIS10000 REPEAT 34, CORRECTED DATA

FILE DAS DATA NIS10000 0034 04 1 RAW

18 DEC 90 16 22 38

Test ID ARC
Experiment Number 1
Pulse Number 14859
Pulse Date 30-AUG-1990 13 43 02
Quality 4
SIGNAL Peak [V/M] -99 83 E-03
Peak Time [sec] 0.150 E-06
Rise Time [sec] 9 969 E-09
Decay Time (1/e) [sec] 2/ 23 E 09
Signal/Noise Ratio [dB] 29

Probe type 915500 2
Probe Eu Conv factor 0 1000000E+01 dB
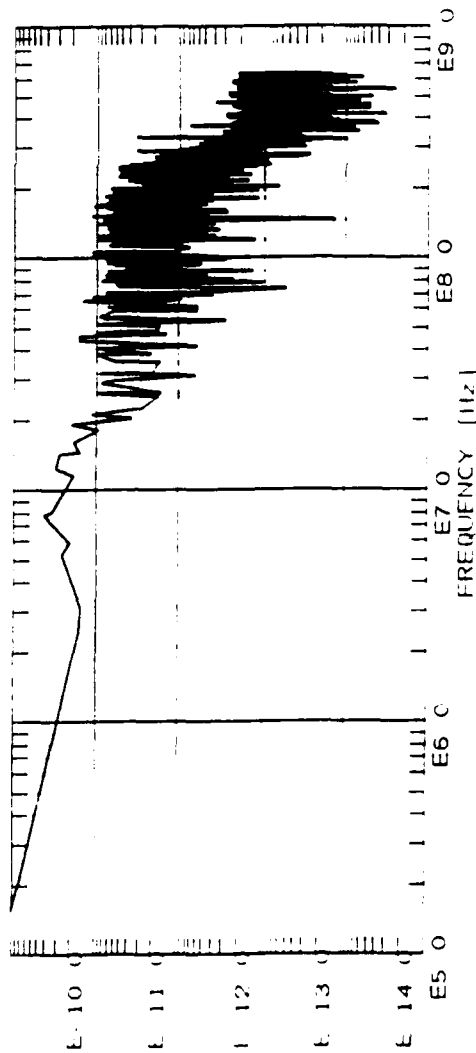Transmitter Gain [db]
Total Scalar Gain [db] 8

AMPLITUDE [V/M] × 10^3
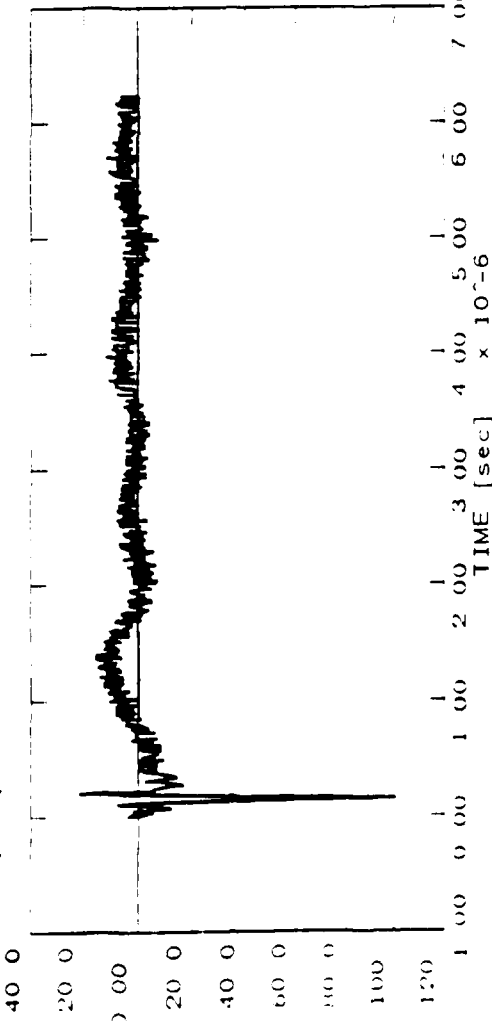40 0
20 0
0 00
20 0
40 0
60 0
100
120

1 00 0 00 1 00 2 00 3 00 4 00 5 00 6 00 7 00
TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]
E-7 0
E-8 0
E 9 0
E 10 0
E 11 0
E 12 0
E 13 0
E5 0 E6 0 E7 0 E8 0 E9 0
FREQUENCY [Hz]

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DDT00000 REPEAT 48, CORRECTED DATA

18 DEC 90 14:54:08   FILE DAS DATA DDT00000 0048 01 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14860
Pulse Date	30-AUG 1990 13:52:54
Quality	4
SIGNAL Peak [eu]	39.42 E+03
Peak Time [sec]	1.197 E-06
Rise Time [sec]	7.593 E-09
Decay Time (1/e) [sec]	28.33 E-09
Signal/Noise Ratio [dB]	31
Probe type	ACD-4
Probe Eu Conv factor	0.8854000E-11
Transmitter Gain [db]	111
Total Scalar Gain [db]	-102
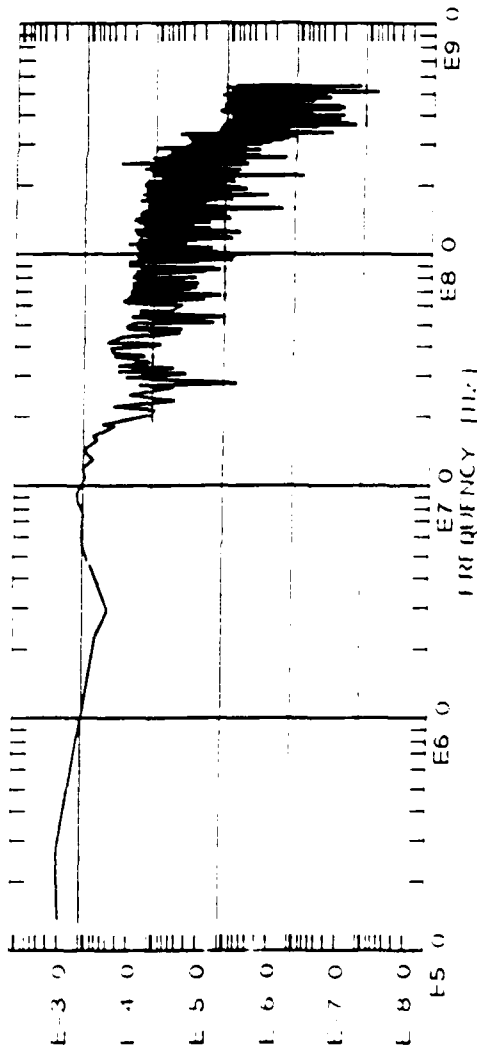
NRL00000 REPEAT 45, CORRECTED DATA

18 DEC 90 17:37:03   FILE DAS DATA NRL 00000 0045 02 1 RAW
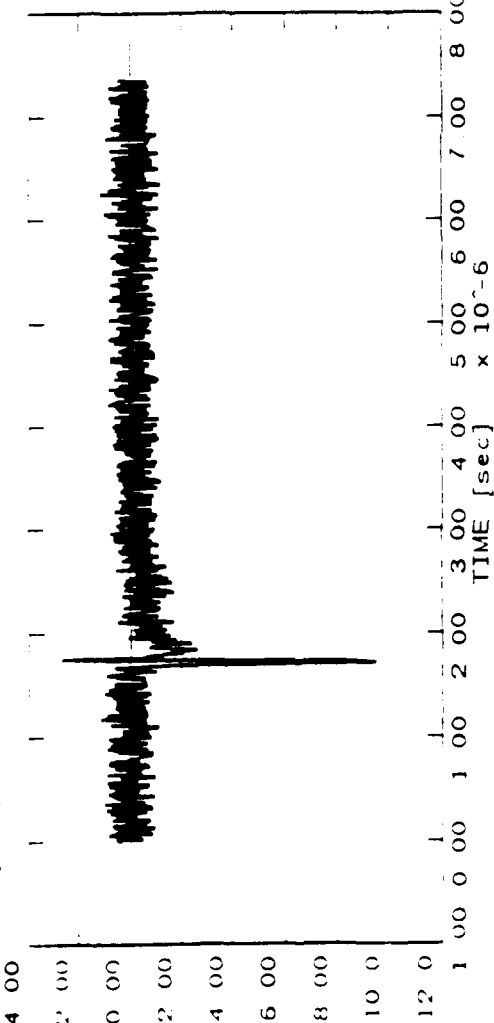
Test ID   ARC
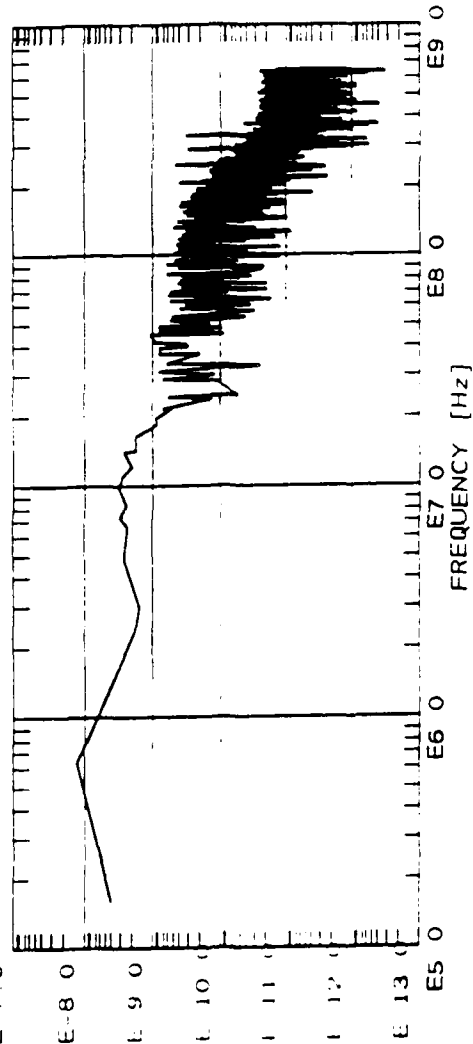Experiment Number   1
Pulse Number   14860
Pulse Date   30-AUG-1990 13 52 20
   Quality   4
SIGNAL   Peak [V/M]   9 431 E 03
          Peak Time [sec]   1 720 E-06
          Rise Time [sec]   22 30 E-09
          Decay Time (1/e) [sec]   15 13 E-09
          Signal/Noise Ratio [dB]   27

Probe type   91550 2
Probe Eu Conv factor   0.1000000E+01
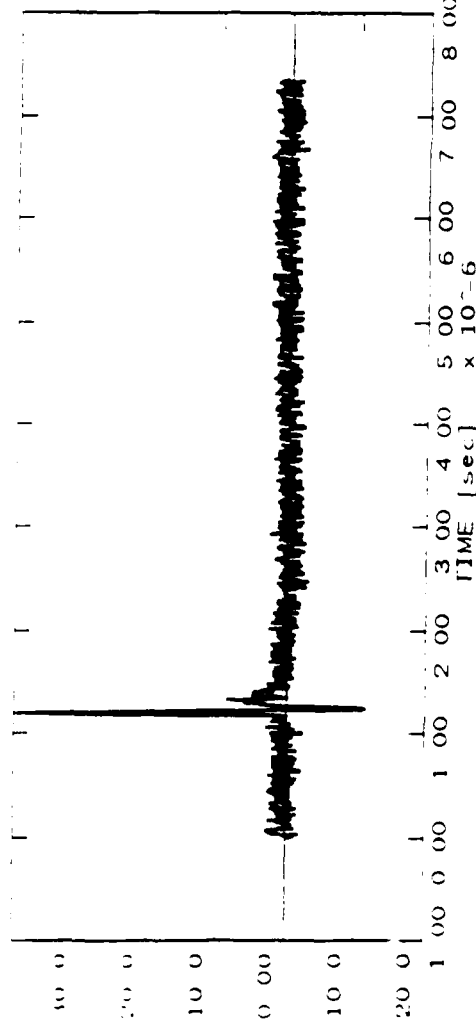Transmitter Gain [db]   28
Total Scalar Gain [db]   28

AMPLITUDE [V/M] x 10 3

TIME [sec] x 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
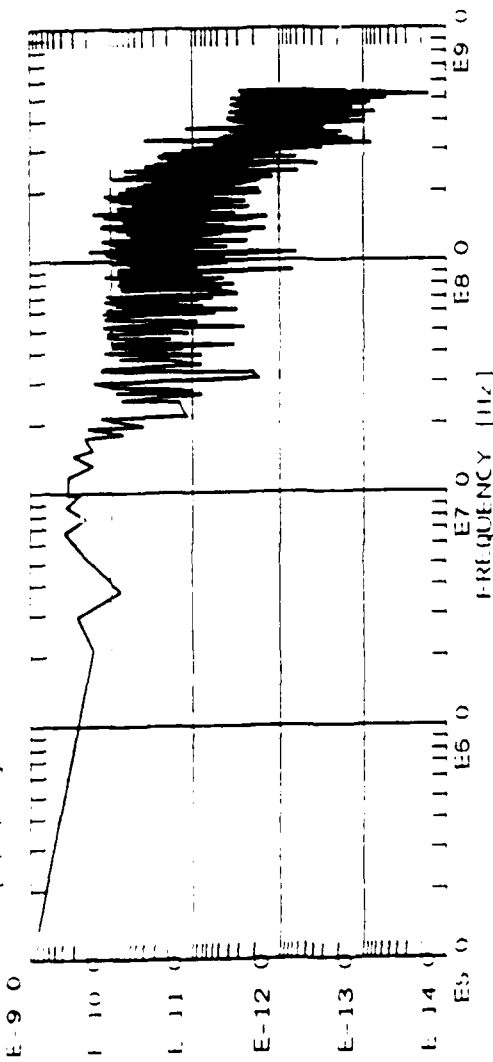
NIST0000 REPEAT 35, CORRECTED DATA

18-DEC-90 16:25:27   FILE: DAS-DATA:NIST0000:0035:04:1:RAW

Test ID	ARC	
Experiment Number	1	
Pulse Number	14860	
Pulse Date	30-AUG-1990 13:52:41	
Quality	4	
SIGNAL: Peak [V/M]		0.107
Peak Time [sec]		0.580 E-06
Rise Time [sec]		13.39 E-09
Decay Time (1/e) [sec]		26.43 E-09
Signal/Noise Ratio [dB]		32
Probe type	91550-2	
Probe Eu Conv factor	0.100000001E+01	
Transmitter Gain [db]	+8	
Total Scalar Gain [db]	8	

DDTOOOOO REPEAT 49, CORRECTED DATA

18 DEC 90 14 55 49   FILE DAG DATA DDTOOOOO 0049 01 1 RAW
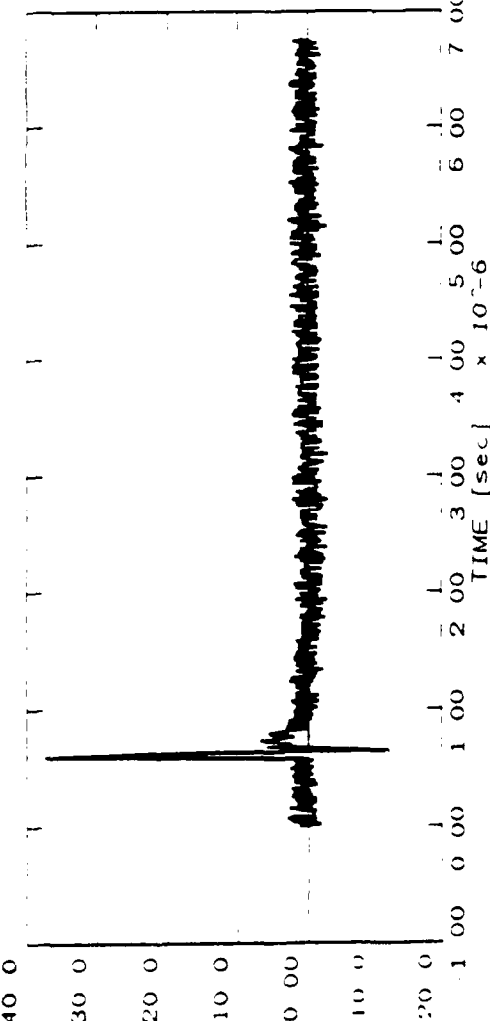
Test ID   ARC
Experiment Number   1
Pulse Number   14861
Pulse Date   30-AUG-1990 13 59 20
Quality   4
SIGNAL Peak [eu]   37 25 E+03
        Peak Time [sec]   0 604 E-06
        Rise Time [sec]   7 435 E-09
        Decay Time (1/e) [sec]   29 00 E-09
        Signal/Noise Ratio [dB]   30

Probe type   ArD 4
Probe Eu Conv factor   0 8854000E-11

Transmitter Gain   [db]   111
Total Scalar Gain   [db]   -102

AMPLITUDE [ ] × 10^3

TIME [sec] × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

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NRL00000 REPEAT 46, CORRECTED DATA

TITLE DA DATA DIR 00000 0046 02 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14861
Pulse Date	30-AUG 1990 13 59 38
Quality	4
SIGNAL: Peak [V/M]	9 751 E-03
Peak Time [sec]	1 356 E-06
Rise Time [sec]	25 01 E-09
Decay Time (1/e) [sec]	11 84 E-09
Signal/Noise Ratio [dB]	26
Probe type	91550 2
Probe Eu Conv factor	0 1000000 +01
Transmitter Gain [db]	+28
Total Scalar Gain [db]	28

AMPLITUDE [V/M] x 10^-3

4 00
2 00
0 00
-2 00
-4 00
6 00
8 00
10 0
12 0

1 00   0 00   1 00   2 00   3 00   4 00   5 00   6 00   7 00   8 00
TIME [sec]   x 10^-6

MAGNITUDE [V/M/Hz]

E-9 0
E-10 0
E 11 0
E 12 0
E 13 0
E 14 0

E5 0   E6 0   E7 0   E8 0   E9 0
FREQUENCY [Hz]

NIST0000 REPEAT 36, CORRECTED DATA

18-DEC 90 16 28 17   FILE DAS DATA NIST0000 0036 04 1 RAW

Test ID   ARC
Experiment Number   1
Pulse Number   14861
Pulse Date   30-AUG 1990 13 58 52
  Quality   4
SIGNAL Peak [V/M]   9/ 97 E 03
        Peak Time [sec]   0 205 E 06
        Rise Time [sec]   8 331 E 09
        Decay Time (1/e) [sec] 26 86 E 09
        Signal/Noise Ratio [dB] 32

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

Transmitter Gain [db]   +8
Total Scalar Gain [db]   8

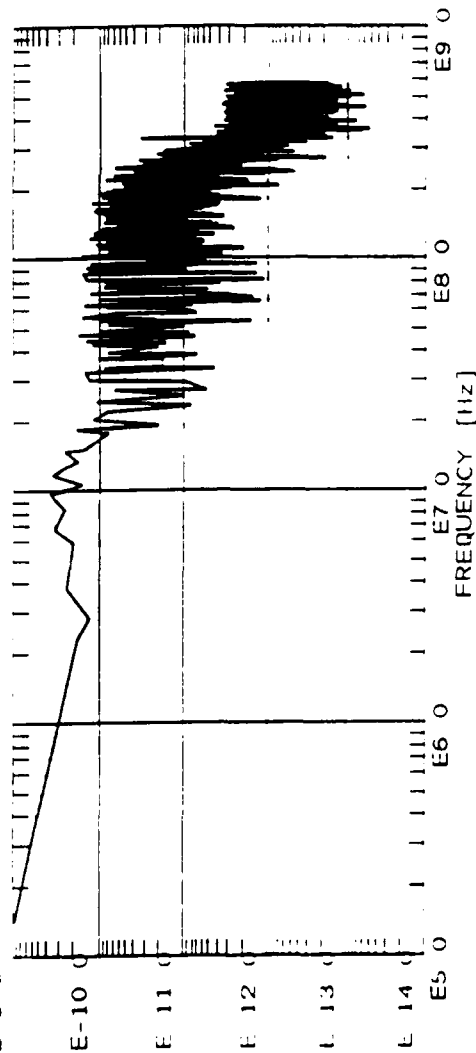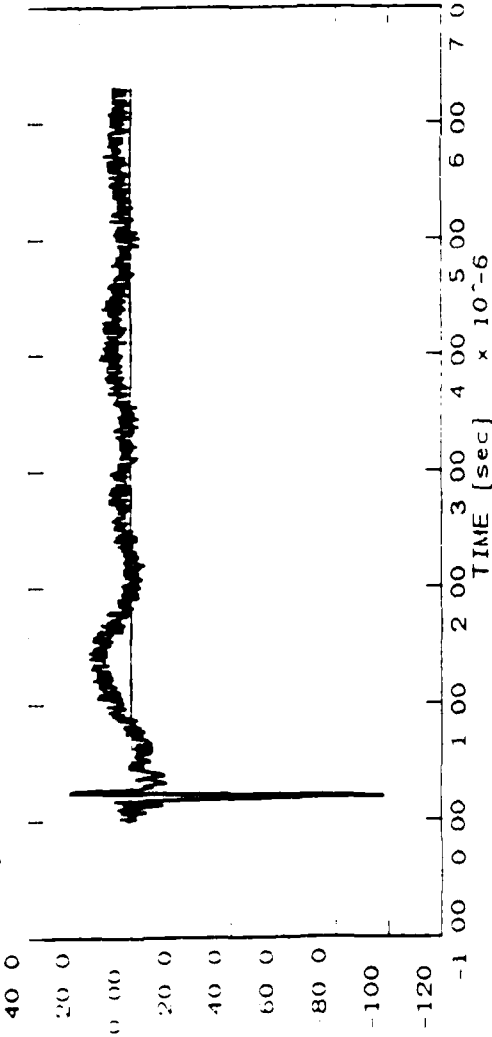AMPLITUDE [V/M] × 10^-3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

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DDT00000 REPEAT 50, CORRECTED DATA

18 DEC 90 14 57 24 FILE DAT DATA DDT00000 0050 01 1 RAW

Test ID   ARC
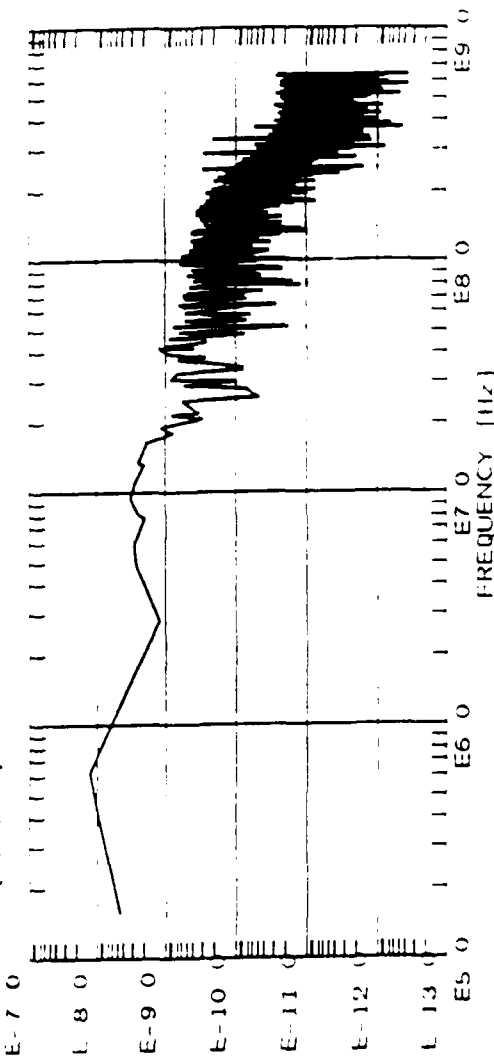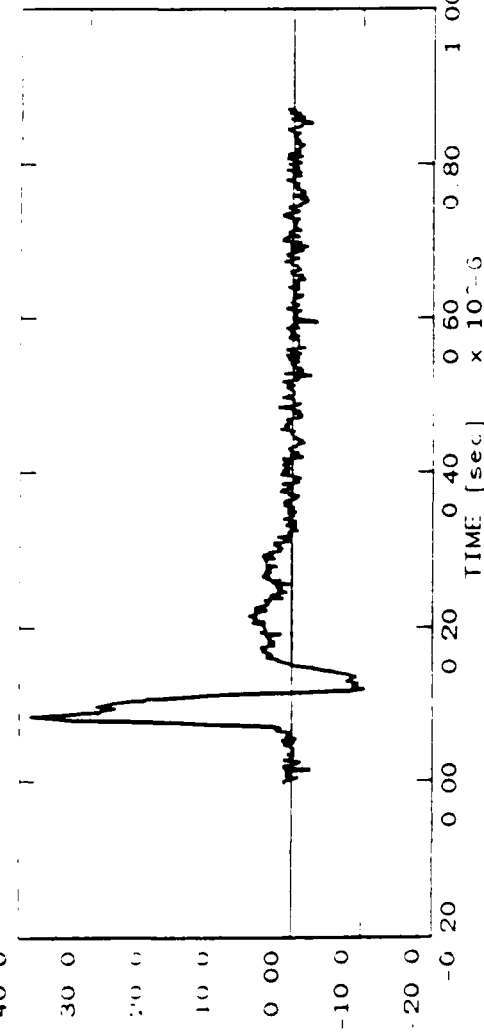Experiment Number   1
Pulse Number   14862
Pulse Date   30-AUG-1990 14 02 29
Quality   4
SIGNAL   Peak [eu]   38 45 E+03
         Peak Time [sec]   85 50 E-09
         Rise Time [sec]   8 156 E-09
         Decay Time (1/e) [sec]   26 73 E-09
         Signal/Noise Ratio [dB]   9

Probe type   ACD-4
Probe Eu Conv factor   0 8854000E-11

Transmitter Gain [db]   +11
Total Scalar Gain [db]   -102

AMPLITUDE [ ]   × 10^3

40 0
30 0
20 0
10 0
0 00
-10 0
-20 0
-0 20   0 00   0 20   0 40   0 60   0 80   1 00
                TIME [sec]   × 10^-6

MAGNITUDE [/Hz]
E-2 0
E 3 0
E 4 0
E 5 0
E 6 0
E 7 0
E6 0   E7 0   E8 0   E9 0
            FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

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18 DEC 90 17 40 19   FILE DAS DATA NRL 00000 0047 02 1 RAW

AMPLITUDE [V/M] × 10^3

Test ID .... ARC
Experiment Number 1
Pulse Number 14862
Pulse Date 30-AUG-1990 14 02 48
Quality 4
SIGNAL:
  Peak [V/M] 9 135 E-03
  Peak Time [sec] 99 54 E-09
  Rise Time [sec] .... 22 52 E 09
  Decay Time (1/e) [sec] .... 14 13 E 09
  Signal/Noise Ratio [dB] 6

Probe type 91550 2
Probe Eu Conv factor .... 0 1000000E+01
Transmitter Gain [db] 28
Total Scalar Gain [db] 28

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

NISTOOOO REPEAT 37, CORRECTED DATA
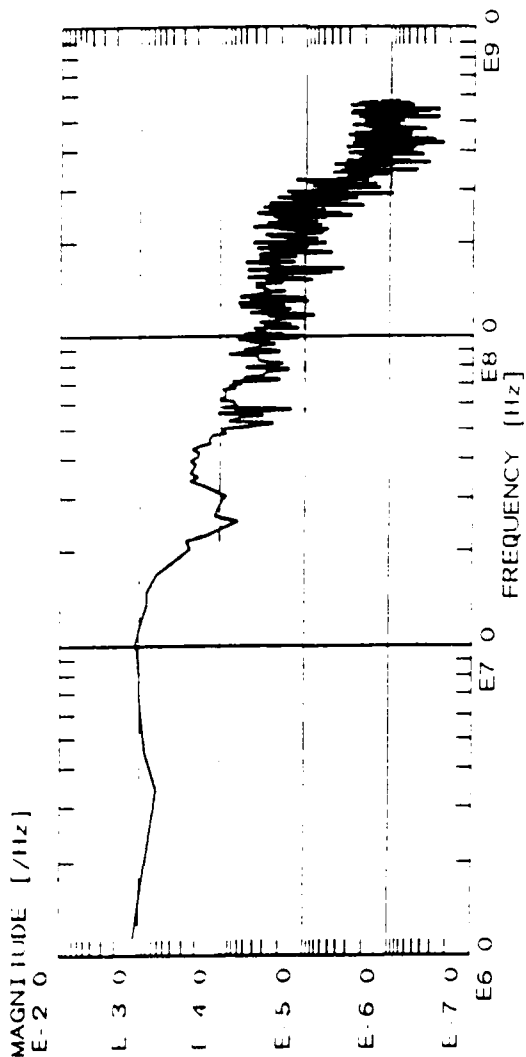
Test ID   ARC
Experiment Number   1
Pulse Number   14862
Pulse Date   30-AUG 1990 14 03 05
Quality   4

SIGNAL Peak [V/M]   0 102
        Peak Time [sec]   0 409 E 06
        Rise Time [sec]   9 141 E 09
        Decay Time (1/e) [sec]   26 32 E 09
        Signal/Noise Ratio [dB]   31

Probe type   91550 2
Probe Eu Conv factor   0 10000001 +01

Transmitter Gain [db]   0
Total Scalar Gain [db]   7 00

FILE DAC DATA NISTOOOO 0037 04 1 RAW

AMPLITUDE [V M]

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
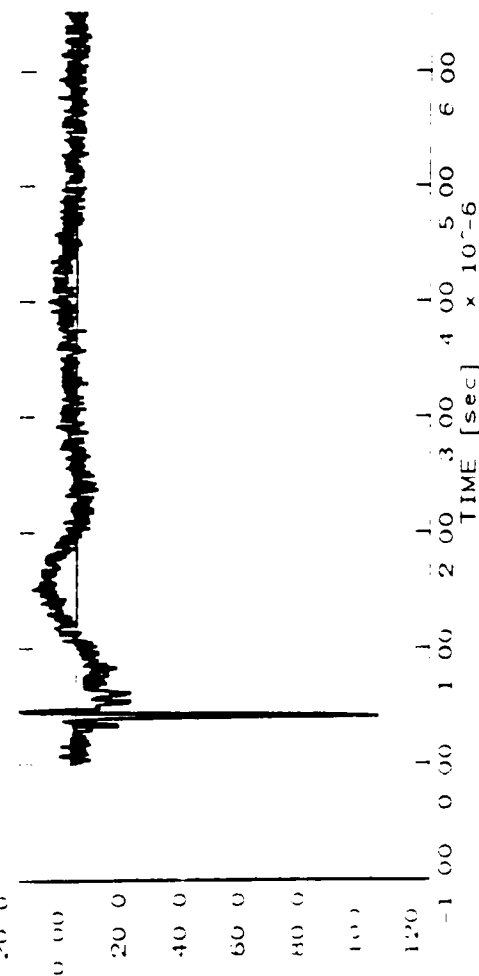
DDT00000 REPEAT 51, CORRECTED DATA

FILE DK, DATA DDT00000 0051 01 1 RAW

18 DEC 90 14 59 04 x 10^3

AMPLITUDE [ ] x 10^3

Test ID	ARC
Experiment Number	1
Pulse Number	14863
Pulse Date	30-AUG-1990 14 09 14
Quality	4
SIGNAL Peak [eu]	38 76 E+03
Peak Time [sec]	0 868 E-06
Rise Time [sec]	9 336 E-09
Decay Time (1/e) [sec]	27 86 E-09
Signal/Noise Ratio [dB]	34
Probe type	ACD 4
Probe Eu Conv factor	0 88540000E-11
Transmitter Gain [db]	111
Total Scalar Gain [db]	-102

TIME [sec] x 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

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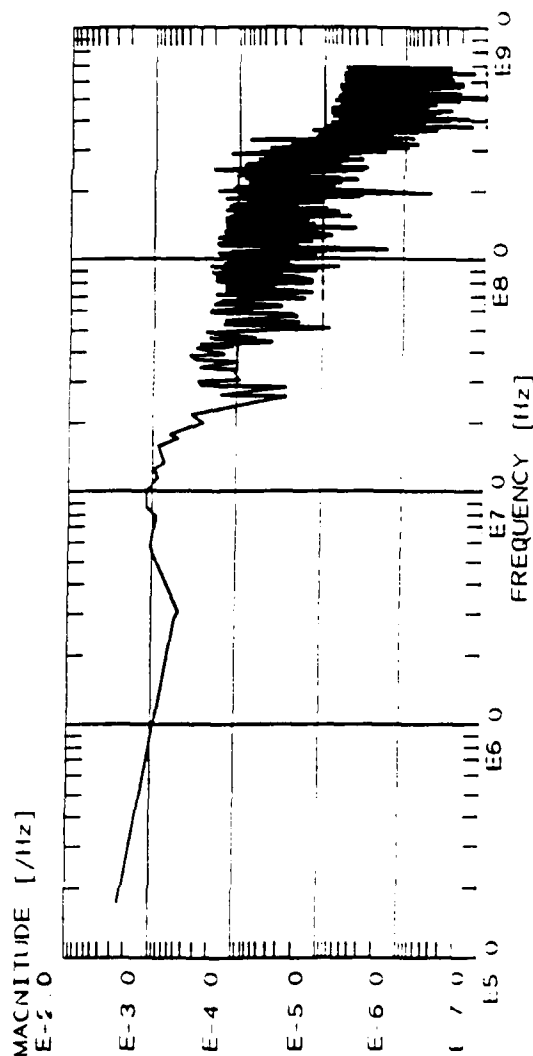
NRL00000 REPEAT 48, CORRECTED DATA

18-DEC-90 17 41 59   FILE DAS DATA NRL00000 0048 02 1 RAW
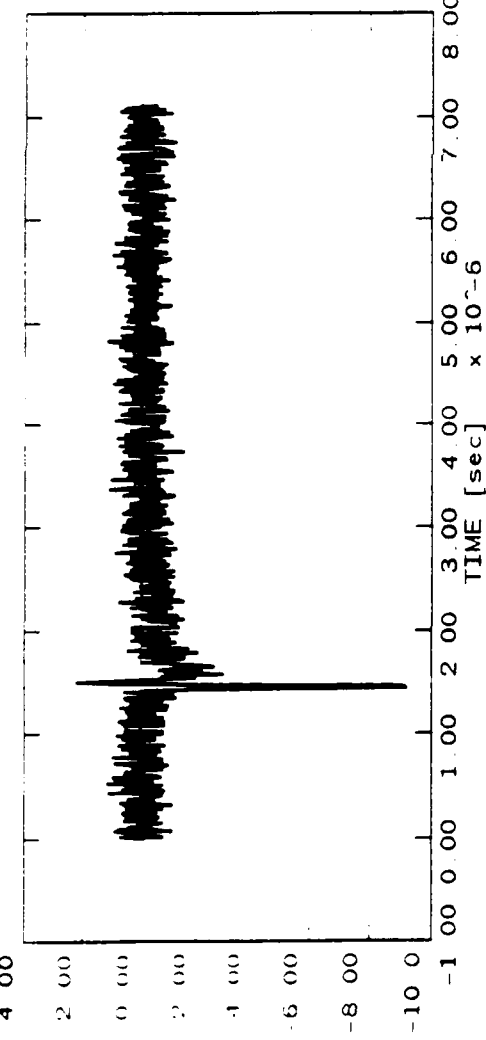
Test ID .... ARC
Experiment Number 1
Pulse Number 14863
Pulse Date 30-AUG-1990 14 09 33
Quality 4
SIGNAL   Peak [V/M] .... 9 153 E 03
          Peak Time [sec] .... 1 455 E 06
          Rise Time [sec] .... 9 120 E 09
          Decay Time (1/e) [sec] 28 90 E 09
          Signal/Noise Ratio [dB] 24

Probe type 91550-2
Probe Eu Conv factor .... 0.1000000E+01

Transmitter Gain [db] .... +28
Total Scalar Gain [db] 28

FOR OFFICIAL USE ONLY

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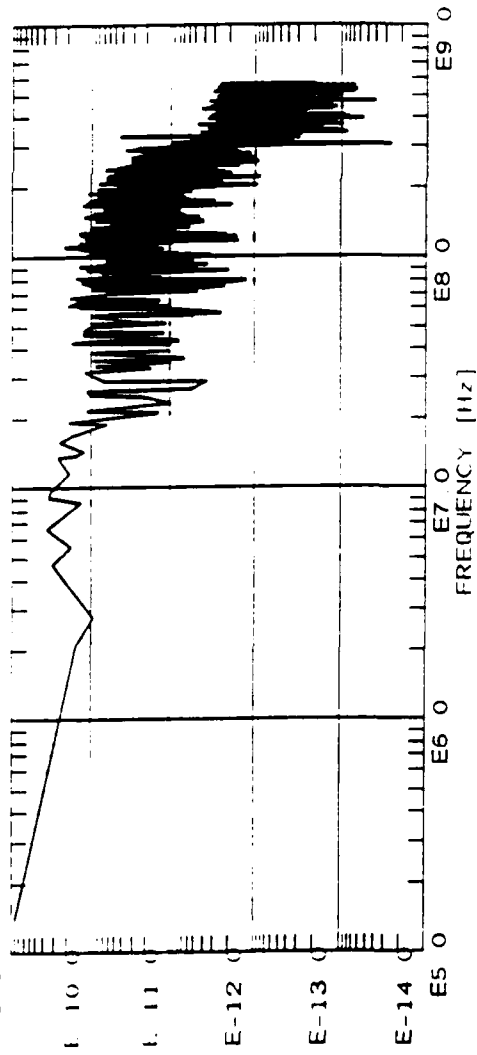
NISTOOOU REPEAT 38, CORRECTED DATA

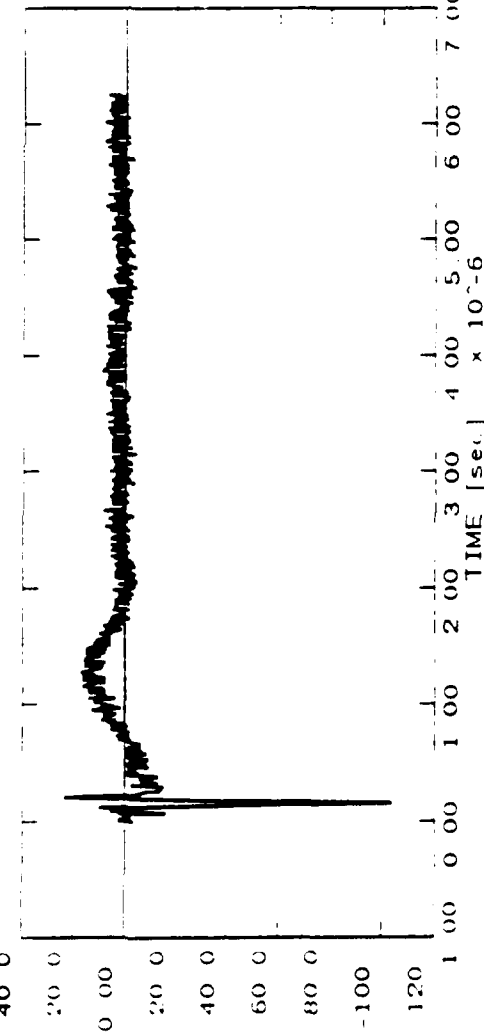18 DEC 90   16 31 48   FILE DAS DATA NISTOOOO 0038 04 1 RAW

AMPLITUDE [V M] × 10^-3

Test ID   ARC
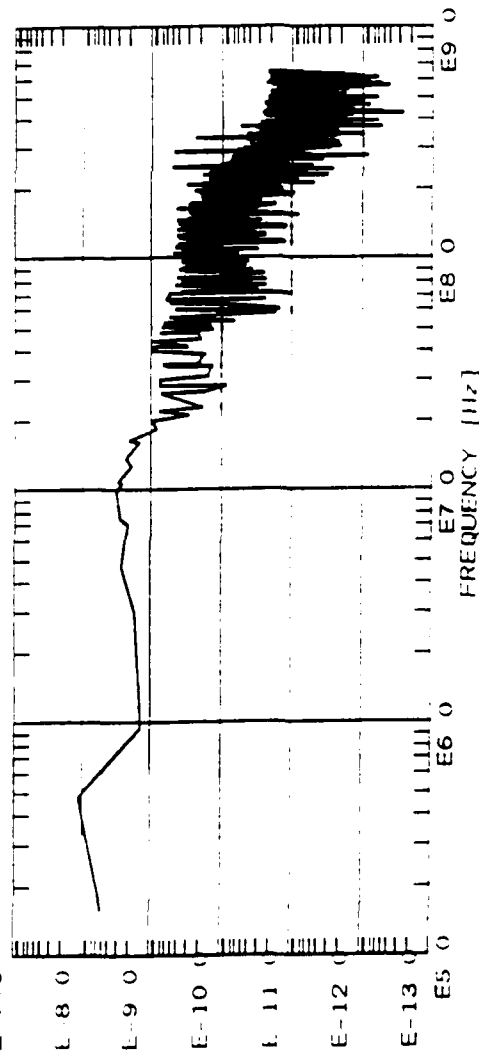Experiment Number   1
Pulse Number   14863
Pulse Date   30-AUG 1990 14 03 5/
Quality   4
SIGNAL Peak [V/M]   0 103
        Peak Time [sec]   0 152 L 06
        Rise Time [sec]   10 40 E-09
        Decay Time (1/e) [sec]   25 85 E-09
        Signal/Noise Ratio [dB]   30

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

Transmitter Gain [db]   :8
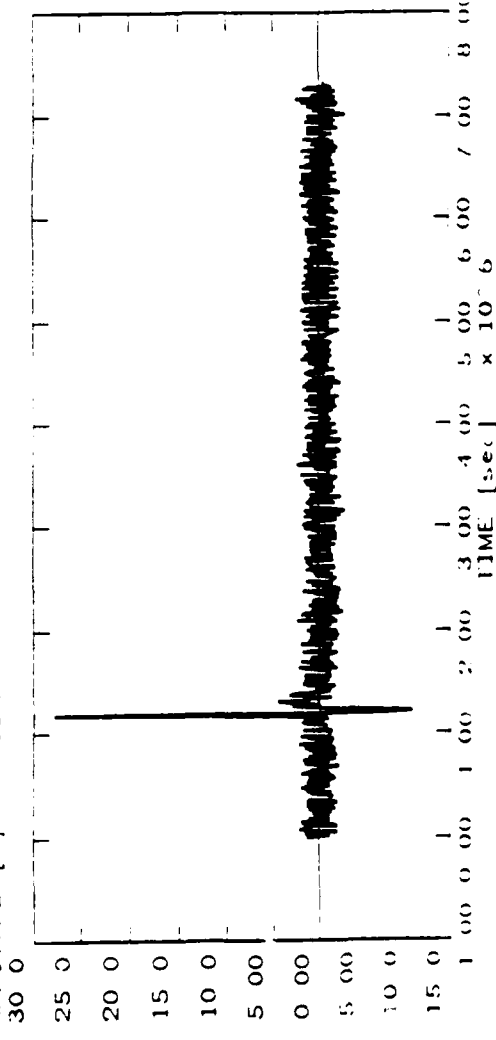00 Total Scalar Gain [db]   8

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

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DD100000 REPEAT 52, CORRECTED DATA
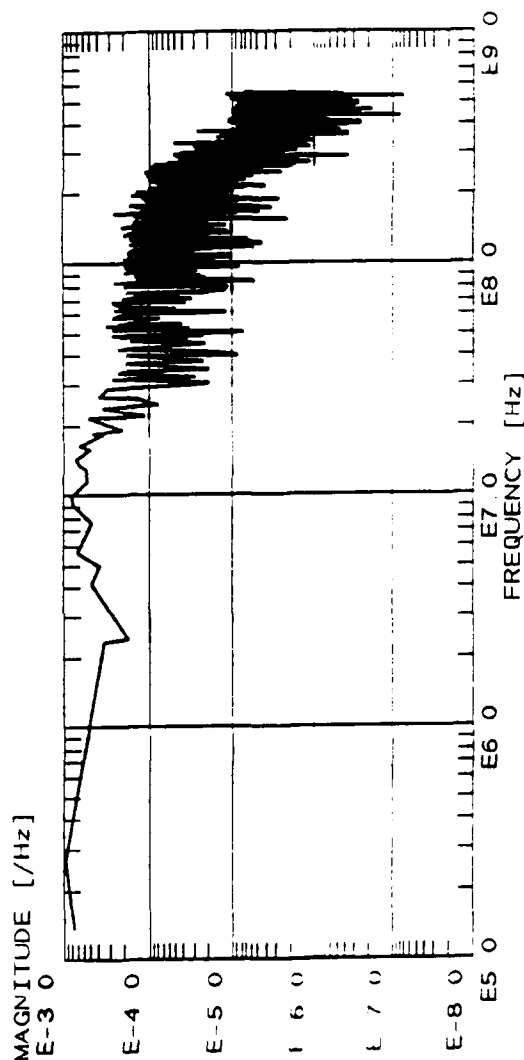
18 DEC 90 15 00 45   FILE DAS DATA DD100000 0052 01 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14864
Pulse Date	30-AUG-1990 14 15 02
Quality	4
SIGNAL Peak [eu]	27 63 E+03
Peak Time [sec]	1 186 E-06
Rise Time [sec]	7 054 E-09
Decay Time (1/e) [sec]	39 52 E-09
Signal/Noise Ratio [dB]	28
Probe type	ACD 4
Probe Eu Conv Factor	0 88540000E 11
Transmitter Gain [db]	111
Total Scalar Gain [db]	102

AMPLITUDE [ ] x 10^3

30 0
25 0
20 0
15 0
10 0
5 00
0 00
5 00
10 0
15 0

1 00 0 00   1 00   2 00   3 00   4 00   5 00   6 00   7 00   8 00
× 10^-6
TIME [sec]

MAGNITUDE [/Hz]

E-3 0
E-4 0
E-5 0
E-6 0
E-7 0
E-8 0

E5 0   E6 0   E7 0   E8 0   E9 0
FREQUENCY [Hz]

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NRLO0000 REPEAT 49, CORRECTED DATA

FILE: DAS. DATA NRL00000 0049 02 1 RAW

18 DEC 90 17 43 40
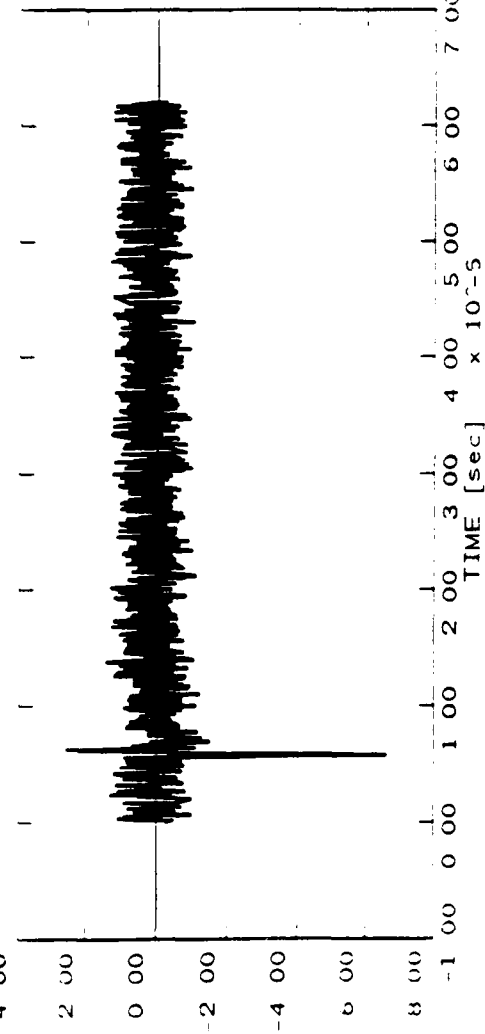
Test ID   ARC.
Experiment Number   1
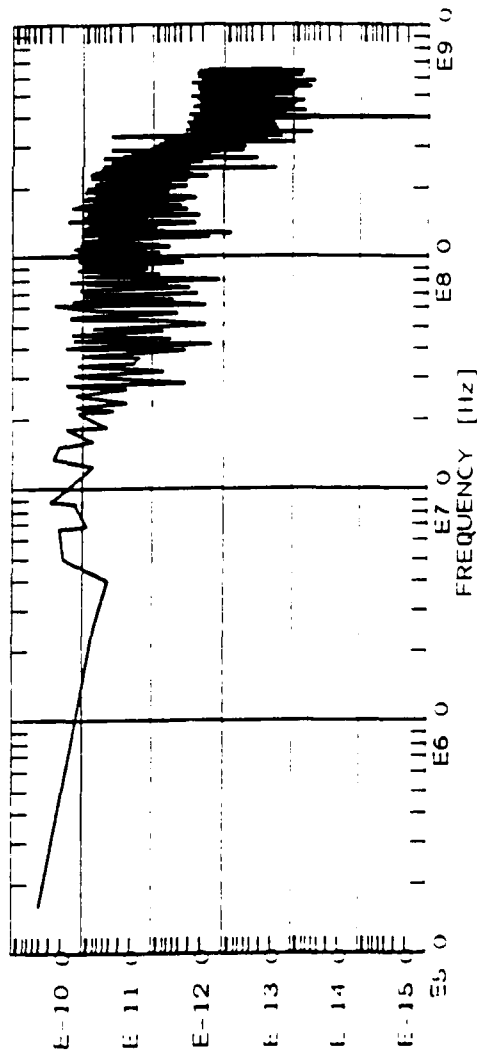Pulse Number   14864
Pulse Date   30-AUG-1990 14 15 24
Quality   4
SIGNAL: Peak [V/M]   6 550 E-03
        Peak Time [sec]   0 584 E-06
        Rise Time [sec]   15 88 E-09
        Decay Time (1/e) [sec]   41 87 E 09
        Signal/Noise Ratio [dB]   22

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

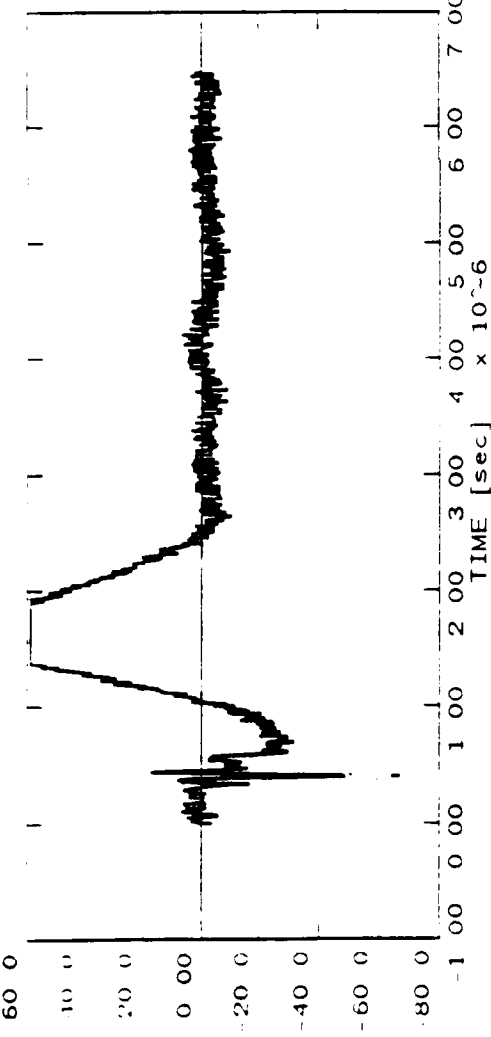Transmitter Gain [db]   128
Total Scalar Gain [db]   28

AMPLITUDE [V/M] × 10^-3

TIME [sec]   × 10^-5

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

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NIST0000 REPEAT 39, CORRECTED DATA

18 DEC 90 16 33 28

FILE DAS DATA NIST0000 0039 04 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14864
Pulse Date	30-AUG 1990 14 16 00
Quality	4

SIGNAL
Peak [V/M] 66 59 E 03
Peak Time [sec] 0 412 E-06
Rise Time [sec] 6 060 E-09
Decay Time (1/e) [sec] 1 796 E 06
Signal/Noise Ratio [dB] 28

Probe type 91550-2
Probe Eu Conv factor 0 1000000E+01
Transmitter Gain [db] +8
Total Scalar Gain [db] 8

AMPLITUDE [V/M] × 10^3
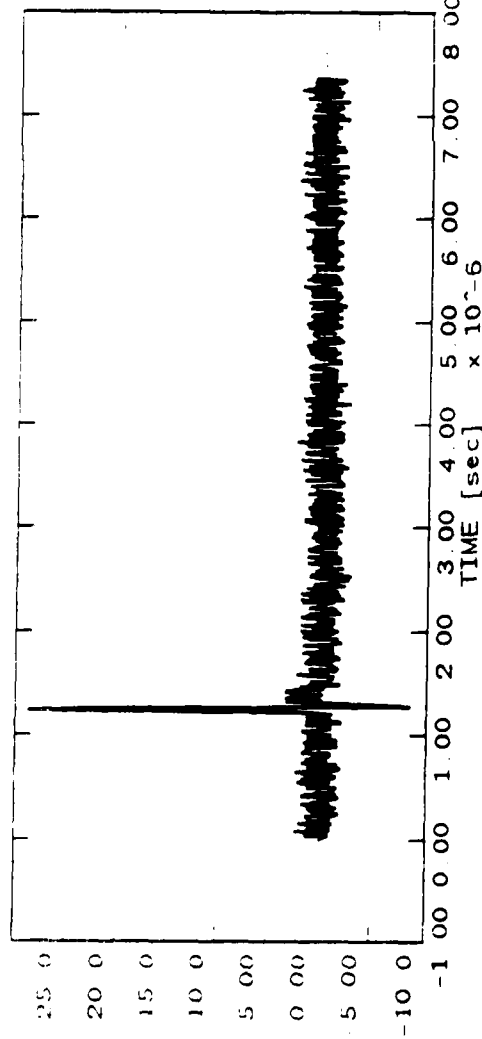
60 0

10 00

20 0

0 00

20 0

40 0

60 0

80 0

-1 00 0 00 1 00 2 00 3 00 4 00 5 00 6 00 7 00

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

E-7 0

1 8 0

1 9 0

E-10 0

E-11 0

E-12 0

E-13 0

E5 0 E6 0 E7 0 E8 0 E9 0

FREQUENCY [Hz]
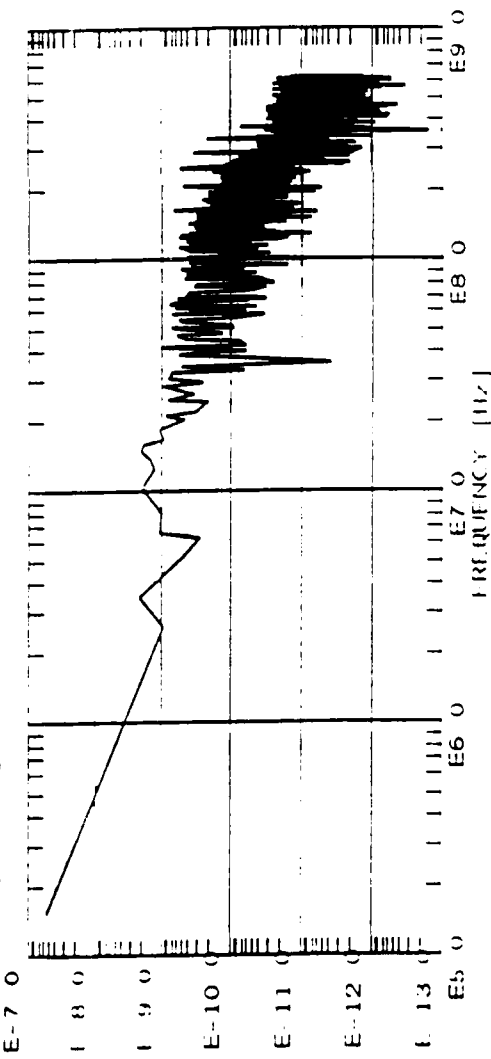
DDT0000C REPEAT 53, CORRECTED DATA

18-DEC-90 15 02 26

FILE DAS DATA DDT00000 0053 01 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14865
Pulse Date	30-AUG-1990 14 19 26
Quality	4

SIGNAL

Peak [eu]	28 74	E+03
Peak Time [sec]	1 241	E-06
Rise Time [sec]	10 00	E-09
Decay Time (1/e) [sec]	16 37	E-09
Signal/Noise Ratio [dB]	31	

Probe type	ACD-4
Probe Eu Conv factor	0 8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [ ] × 10^3

TIME [sec] × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

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NRLOOOOO REPEAT 50, CORRECTED DATA

Test ID	ARC
Experiment Number	1
Pulse Number	14865
Pulse Date	30-AUG 1990 14 18 22
Quality	4
SIGNAL: Peak [V/M]	7 246 E-03
Peak Time [sec]	1 701 E-06
Rise Time [sec]	12 97 E-09
Decay Time (1/e) [sec]	43 92 E-09
Signal/Noise Ratio [dB]	21
Probe type	91550 2
Probe Eu Conv factor	0 1000000L,01
Transmitter Gain [db]	28
Total Scalar Gain [db]	28

NISTOOOO REPEAT 40, CORRECTED DATA

AMPLITUDE [V/M] × 10 3

Test ID	ARC
Experiment Number	1
Pulse Number	14865
Pulse Date	30-AUG-1990 14 18 59
Quality	4
SIGNAL Peak [V/M]	83 38 E-03
Peak Time [sec]	1 268 E-06
Rise Time [sec]	0 400 E-06
Decay Time (1/e) [sec]	0 628 E-06
Signal/Noise Ratio [dB]	31

Probe type 915502
Probe Eu Conv factor 0 1000000E+01
Transmitter Gain [db] 18
Total Scalar Gain [db] 8

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

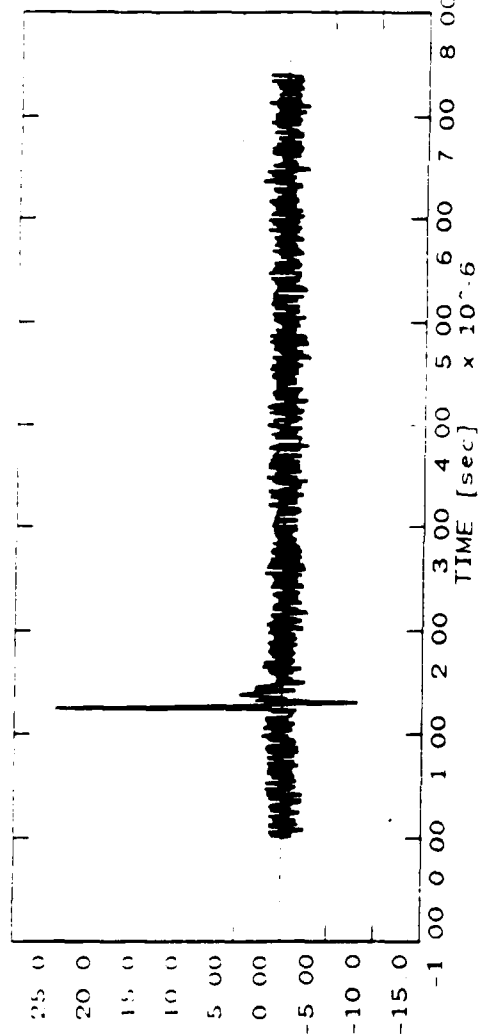D-75

DDT00000 REPEAT 54, CORRECTED DATA

18-DEC 90   15 04 07   FILE DAS DATA DD100000 0054 01 1 RAW

AMPLITUDE [ ]   × 10^3

Test ID   ARC
Experiment Number   1
Pulse Number   1480
Pulse Date   30-AUG 1990 14 22 16
Quality   4

SIGNAL   Peak [eu]   29.4/ [0.04]
         Peak Time [sec]   1 267 [06]
         Rise Time [sec]   7 527 [09]
         Decay Time (1/e) [sec]   1/ 20 [09]
         Signal/Noise Ratio [dB]   29

Probe type   ACD-4
Probe Eu Conv factor   0 8854000E 11

Transmitter Gain [db]   +11
Total Scalar Gain [db]   -102

TIME [sec]   × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]
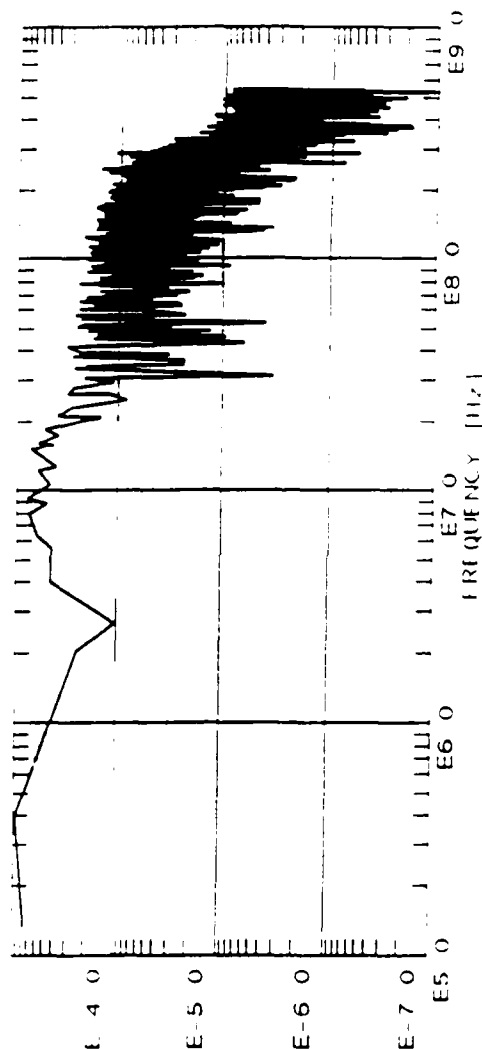
FOR OFFICIAL USE ONLY

NRLOOOOO REPEAT 51, CORRECTED DATA

18 DEC 90 17 47 02   FILE DAS DATA NRL OOOOO OO51 O2 1 RAW

AMPLITUDE [V/M] x 10 3
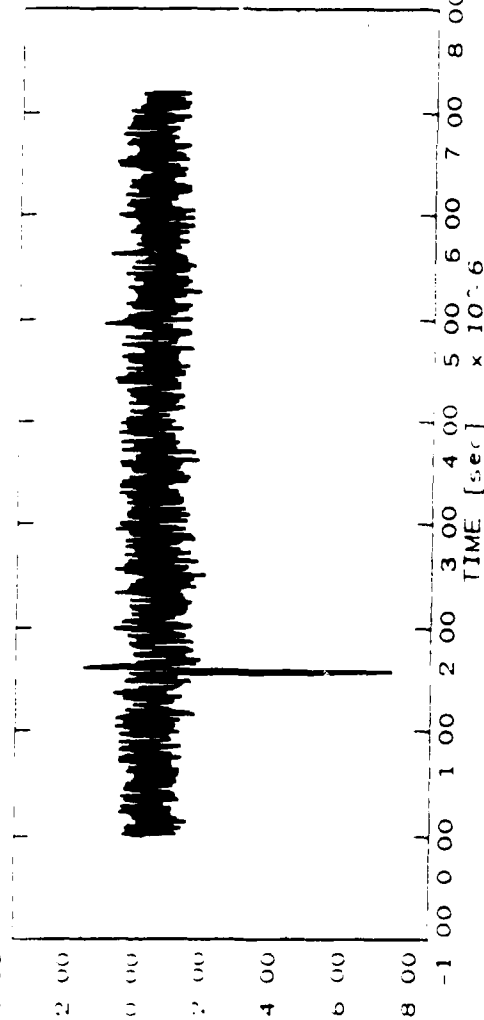
Test ID   ARC
Experiment Number   1
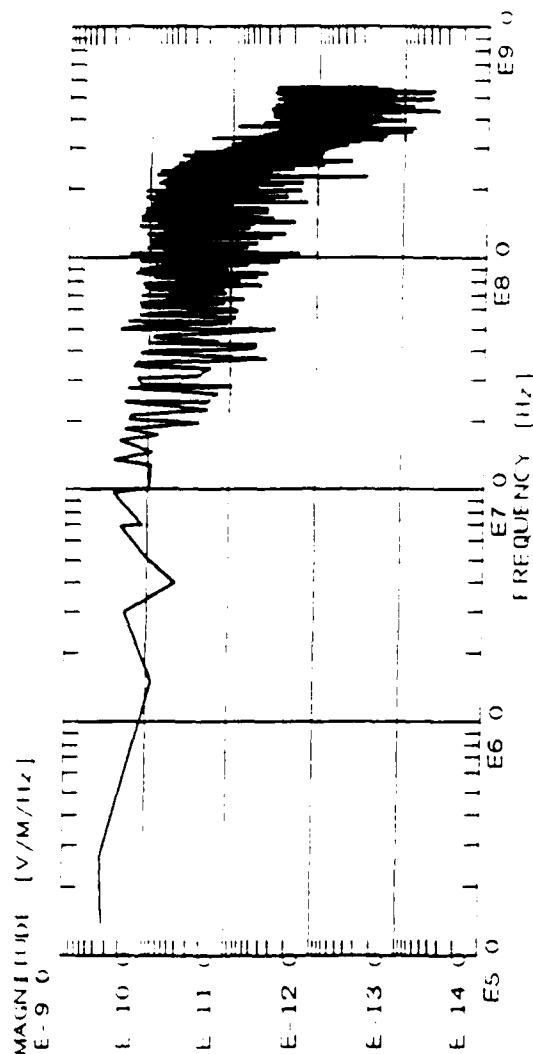Pulse Number   14866
Pulse Date   30 AUG 1990 14 21 23
Quality   4
SIGNAL   Peak [V/M]   6 887 1 03
          Peak Time [sec]   1 576 E 06
          Rise Time [sec]   6 998 E 09
          Decay Time (1/e) [sec]   20 24 E 09
          Signal/Noise Ratio [dB]   22

Probe type   91550 2
Probe Eu Conv Factor   0 1000000E+01
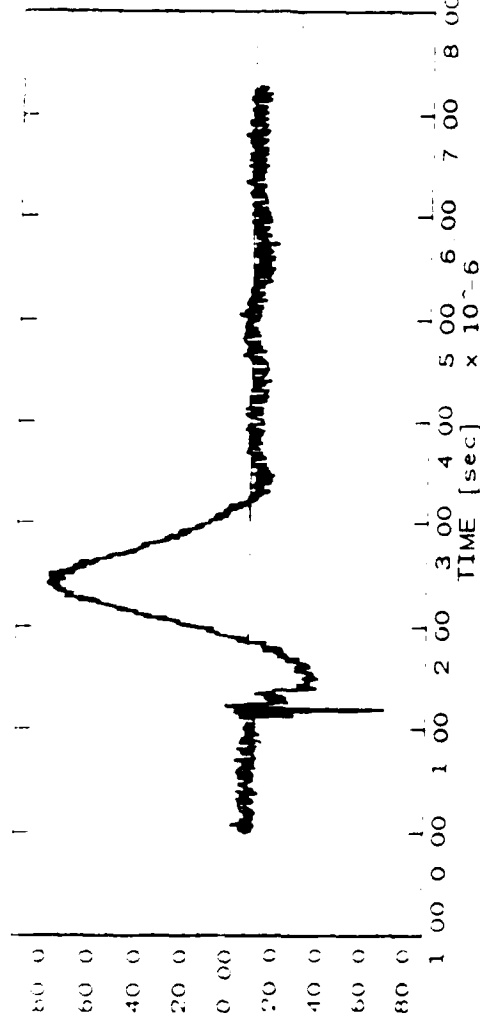Transmitter Gain   [db]   128
Total Scalar Gain [db]   28

TIME [sec] x 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

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NISI0000 REPEAT 41, CORRECTED DATA

Test ID ARC
Experiment Number 1
Pulse Number 14860
Pulse Date 30-AUG-1990 14:21:50
Quality 4
SIGNAL Peak [V/M] 86.77 E 03
Peak Time [sec] 2.421 E 06
Rise Time [sec] 0.427 E 05
Decay Time (1/e) [sec] 0.479 E 06
Signal/Noise Ratio [dB] 30

Probe type 911550 2
Probe Eu Conv. factor 0.10000001 +01
Transmitter Gain [dB]
Total Scalar Gain [dB] 8

AMPLITUDE [V/M] x 10^3
TIME [sec] x 10^-6

MAGNITUDE [V/M/Hz]
FREQUENCY [Hz]

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DDT00000 REPEAT 55, CORRECTED DATA

13 DEC 90 15:05:41   FILE: DAS_DATA DDT00000 0055 01 1 RAW

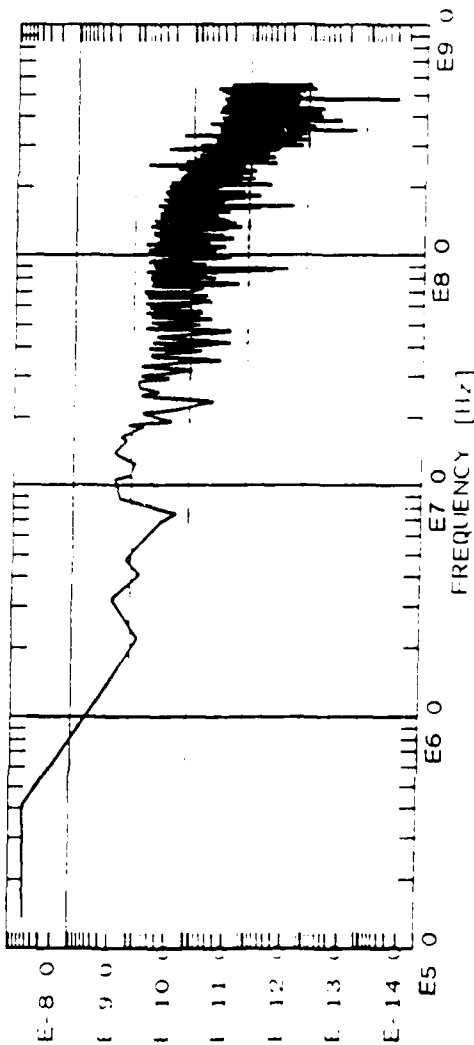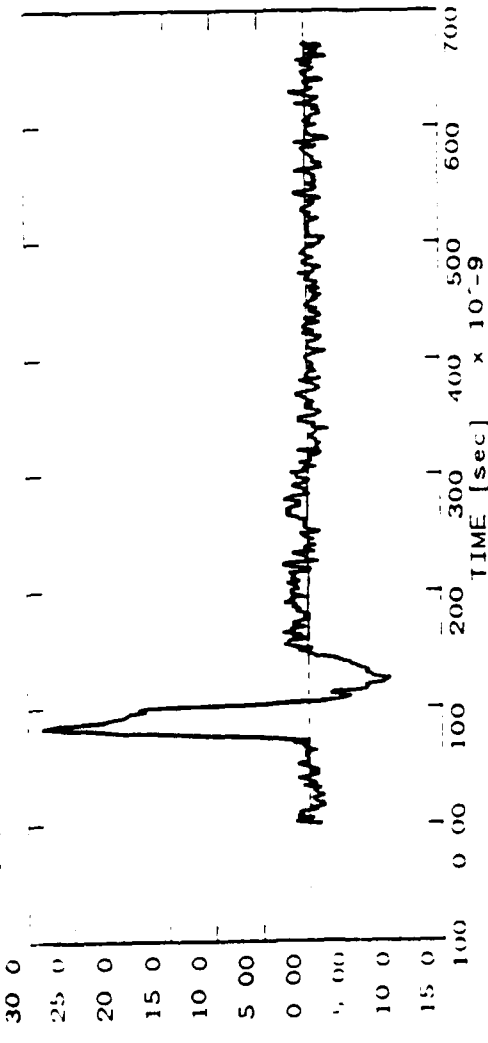Test ID   ARC
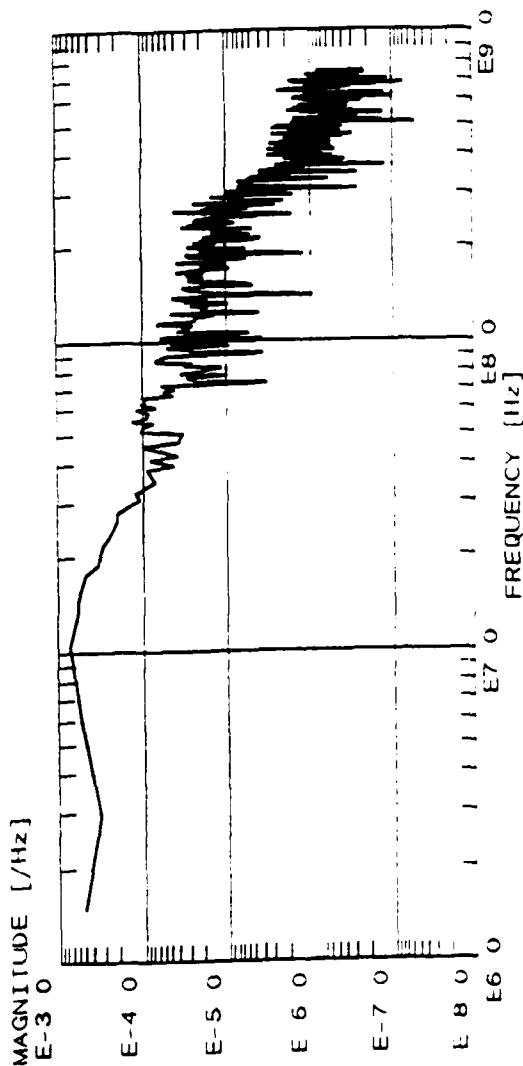Experiment Number   1
Pulse Number   1486/
Pulse Date   30-AUG-1990 14:25:13
Quality   4
SIGNAL Peak [eu]   28.39 E+03
        Peak Time [sec]   84.49 E-09
        Rise Time [sec]   9.066 E-09
        Decay Time (1/e) [sec]   17.77 E-09
        Signal/Noise Ratio [dB]   28

Probe type   ACD-4
Probe Eu Conv factor   0.8854000E-11
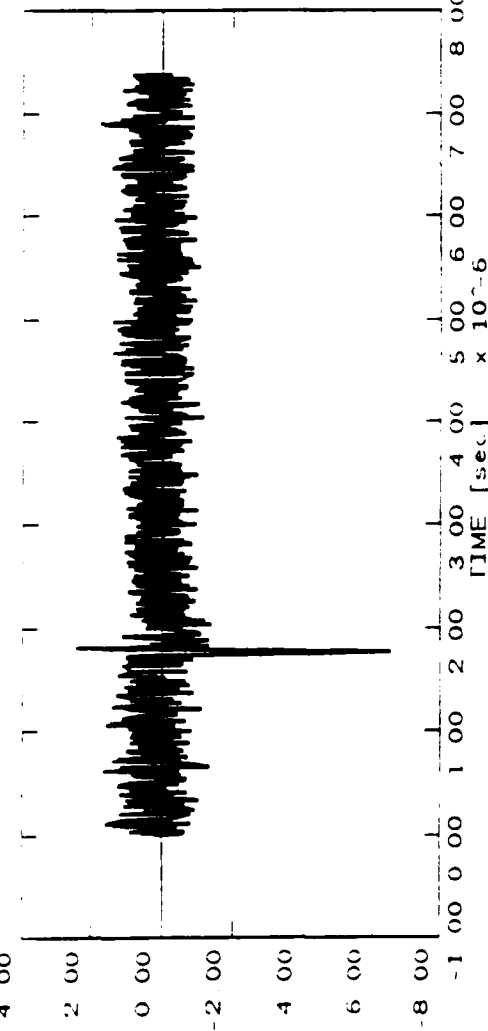Transmitter Gain [db]   111
Total Scalar Gain [db]   102

AMPLITUDE
TIME [sec] × 10^{-9}

MAGNITUDE [/Hz]
FREQUENCY [Hz]

D-79

NRL00000 REPEAT 52, CORRECTED DATA

18 DEC 90 17:48:43   FILE DAY DATA NRL00000 0052 02 1 RAW

Test ID   ARC
Experiment Number   1
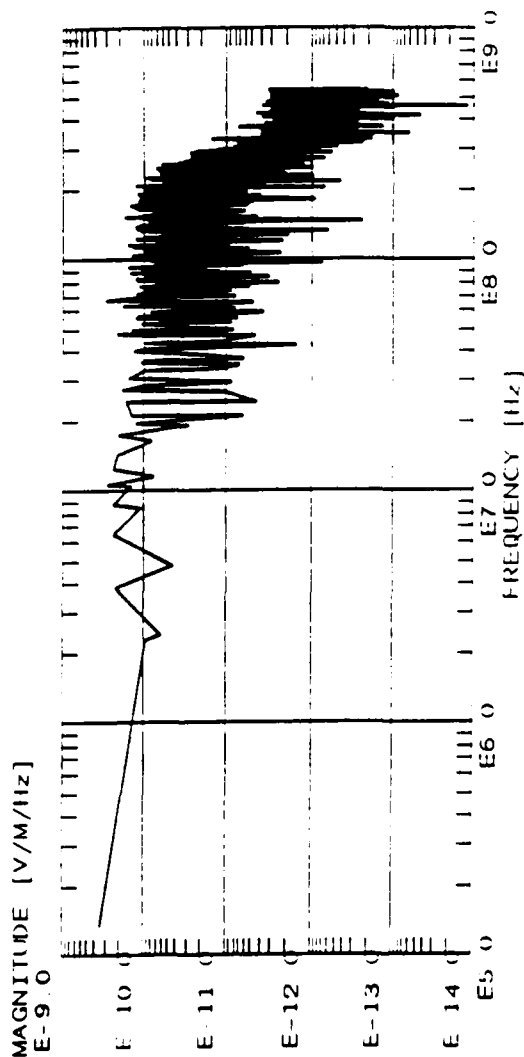Pulse Number   1486/
Pulse Date   30-AUG 1990 14 24 26
Quality   4
SIGNAL Peak [V/M]   6 513 E-03
        Peak Time [sec]   1 773 E-06
        Rise Time [sec]   17 26 E-09
        Decay Time (1/e) [sec]   42 59 E-09
        Signal/Noise Ratio [dB]   20

Probe type   91550-2
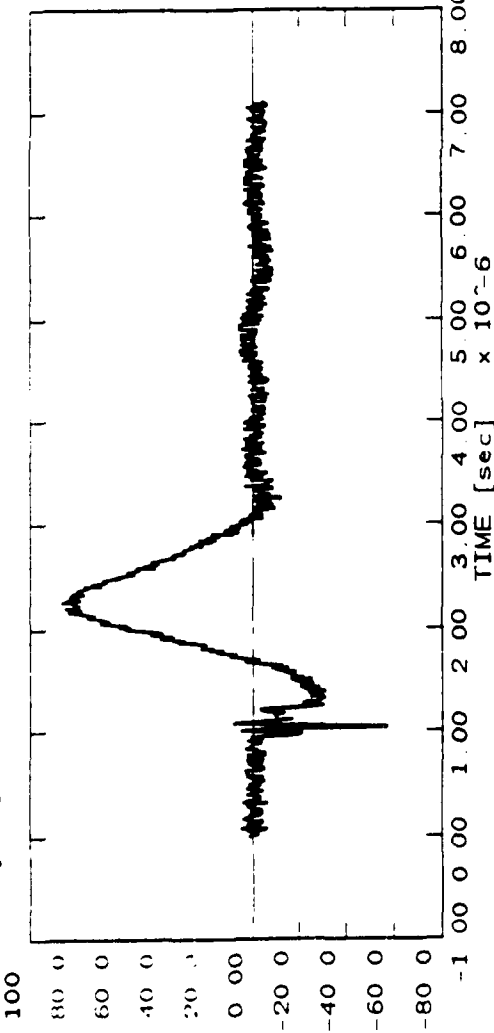Probe Eu Conv Factor   0 10000000E+01
Transmitter Gain   [db]   128
Total Scalar Gain [db]   28

AMPLITUDE [V/M]   × 10^-3
TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]
FREQUENCY [Hz]

D-80

NISTOOOO REPEAT 42, CORRECTED DATA

18-DEC-90   16 38 33   FILE DAS DATA NISTOOOO_0042_04_1 RAW

AMPLITUDE [V/M]   × 10^-3

Test ID   ARC
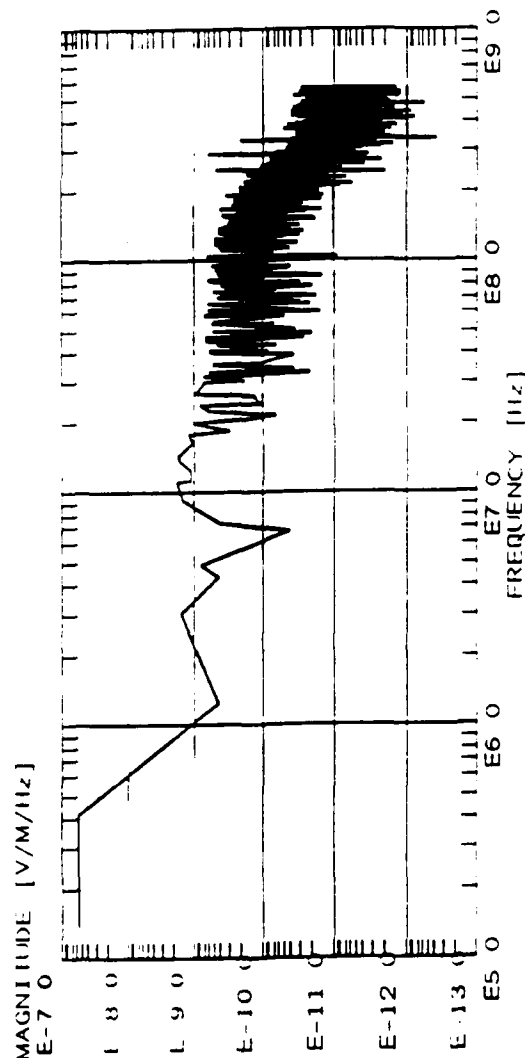Experiment Number   1
Pulse Number   1486/
Pulse Date   30-AUG 1990 14 24 46
   Quality   4
SIGNAL   Peak [V/M]   85 621 E 03
          Peak Time [sec]   2 273 E 06
          Rise Time [sec]   0 420 E 06
          Decay Time (1/e) [sec]   0 498 E 06
          Signal/Noise Ratio [dB]   31

Probe type   91550-2
Probe Eu Conv factor   0.1000000E+01
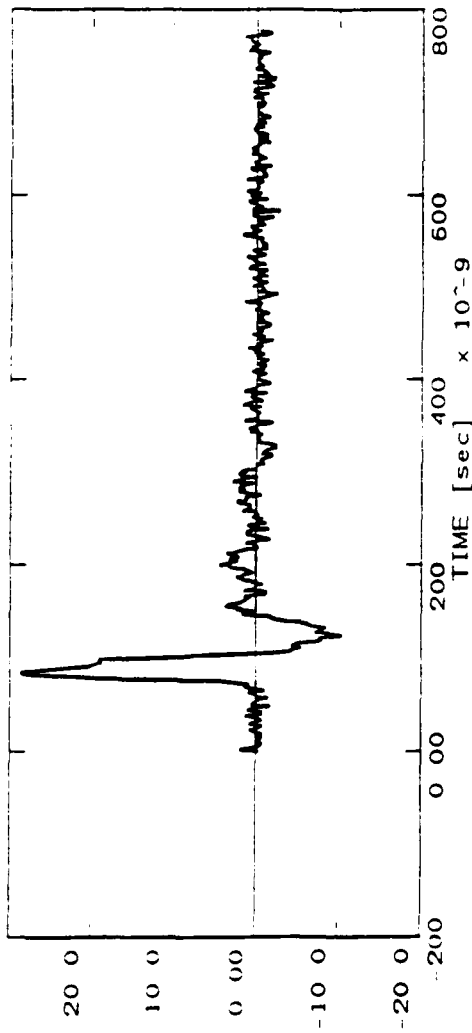
Transmitter Gain [db]   +8
Total Scalar Gain [db]   8

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-81

18 DEC 90 15 07 32   FILE DAS DATA DD100000 0056 01 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14868
Pulse Date	30-AUG-1990 14 28 08
Quality	4
SIGNAL Peak [eu]	28 72 E+03
Peak Time [sec]	84 53 E-09
Rise Time [sec]	7 919 E-09
Decay Time (1/e) [sec]	18 09 E-09
Signal/Noise Ratio [dB]	26
Probe type	ACD-4
Probe Eu Conv factor	0 8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [ ] × 10^3

TIME [sec] × 10^-9

MAGNITUDE [/Hz]

FREQUENCY [Hz]

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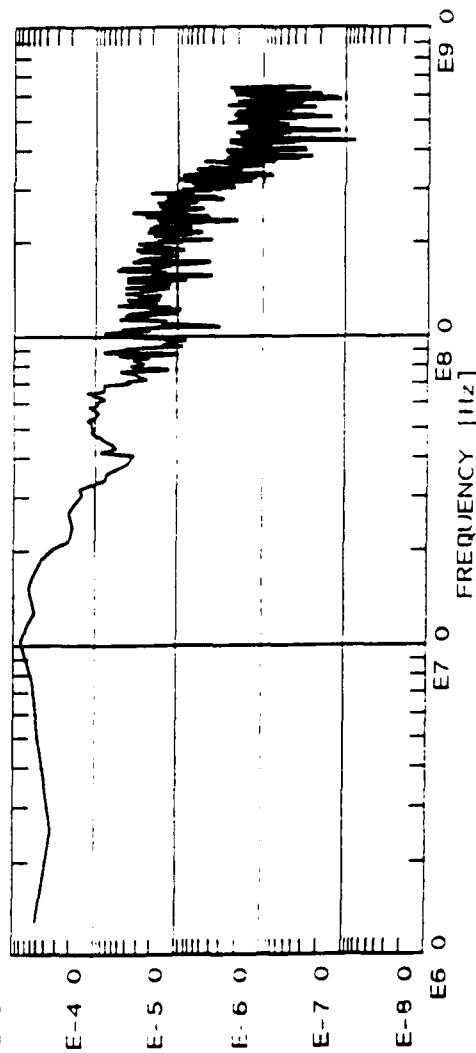
NRL00000 REPEAT 53, CORRECTED DATA
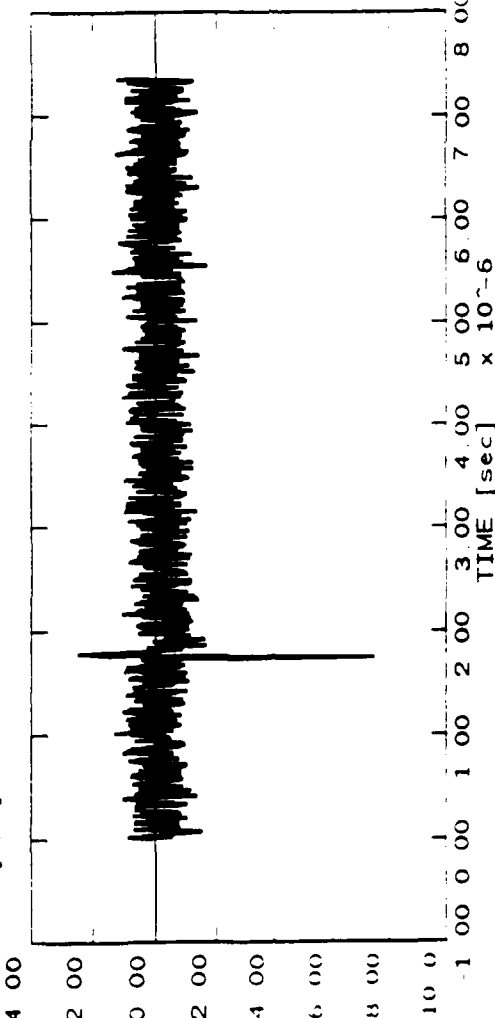
Test ID	ARC
Experiment Number	1
Pulse Number	14868
Pulse Date	30-AUG-1990 14 27 23
Quality	4
SIGNAL: Peak [V/M]	7.399 E-03
Peak Time [sec]	1.747 E-06
Rise Time [sec]	9.276 E-09
Decay Time (1/e) [sec]	18 05 E-09
Signal/Noise Ratio [dB]	22
Probe type	915502
Probe Eu Conv factor	0.1000000t+01
Transmitter Gain [db]	28
Total Scalar Gain [db]	28

AMPLITUDE [V/M] × 10^-3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
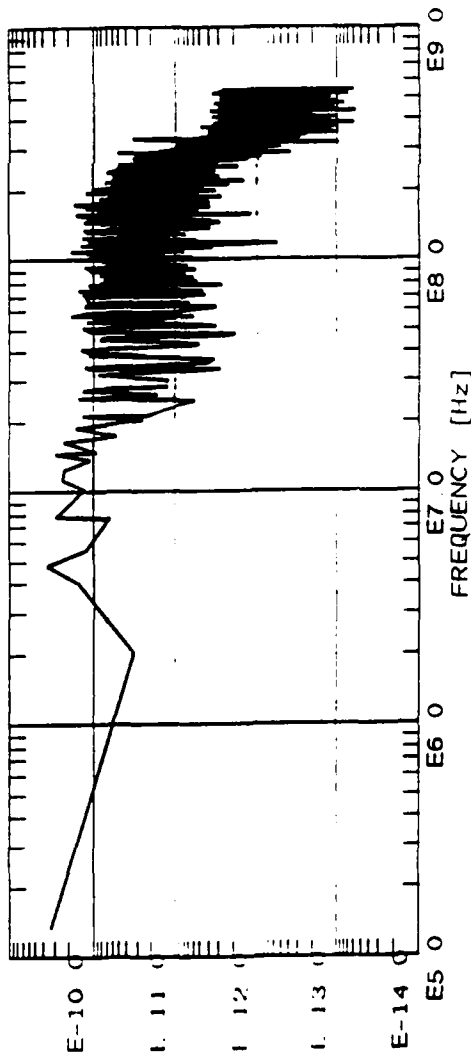
NIST0000 REPEAT 43, CORRECTED DATA

18 DEC 90 16:40:14   FILE DAG DATA NIST0000 0043 04 1 RAW
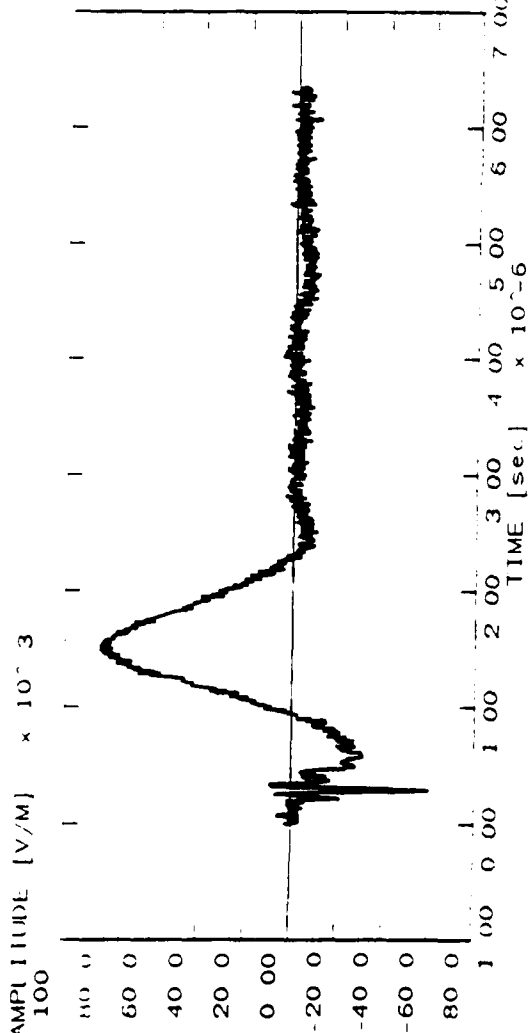
Test ID .... ARC
Experiment Number 1
Pulse Number 14868
Pulse Date 30-AUG 1990 14 27 41
Quality 4
SIGNAL Peak [V/M] .... 84.13 E 03
        Peak Time [sec] 1.536 E-06
        Rise Time [sec] 0.452 E-06
        Decay Time (1/e) [sec] ...... 0.489 E 06
        Signal/Noise Ratio [dB] 30

Probe type 91550-2
Probe Eu Conv Factor .... 0.1000000E+01
Transmitter Gain [db] 18
Total Scalar Gain [db] 0

AMPLITUDE [V/M] × 10^-3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

DDT000000 REPEAT 57, CORRECTED DATA

18 DEC 90 15 09 08

FILE DAS DATA DDT00000 0057 01 1 RAW
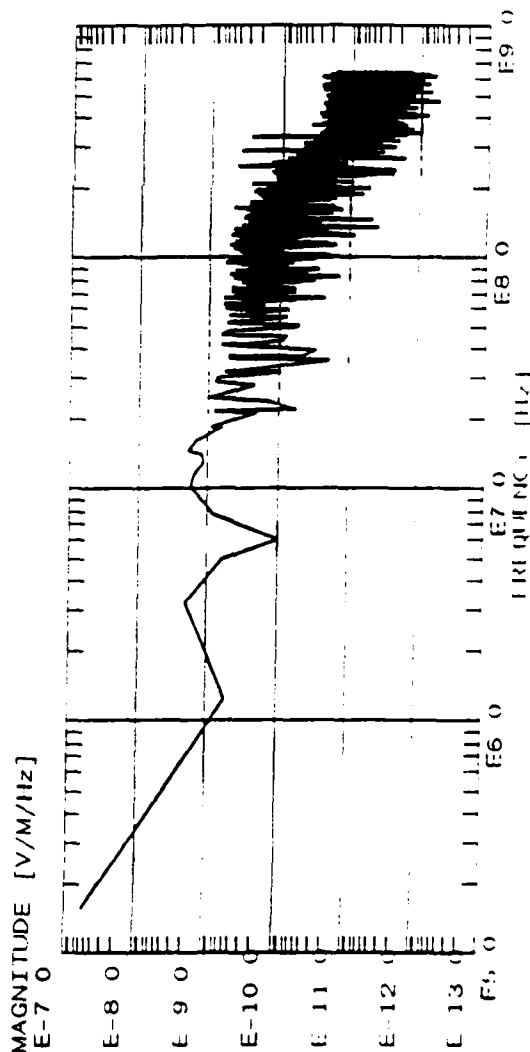
Test ID   ARC
Experiment Number   1
Pulse Number   14869
Pulse Date   30-AUG-1990 14 32 46
Quality   4
SIGNAL Peak [eu]   29 38 E+03
        Peak Time [sec]   83.78 E-09
        Rise Time [sec]   7 708 E-09
        Decay Time (1/e) [sec]   17 46 E-09
        Signal/Noise Ratio [dB]   9

Probe type   ACD-4
Probe Eu Conv factor   0 8854000E-11

Transmitter Gain   [db]   111
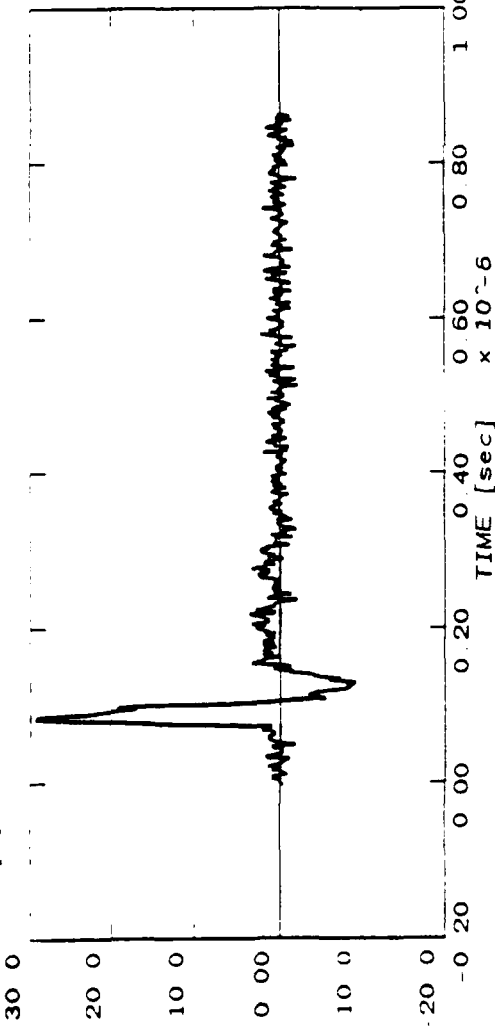Total Scalar Gain   [db]   -102

AMPLITUDE [ ] × 10^3
30 0
20 0
10 0
0 00
10 0
-20 0

-0 20   0 00   0 20   0 40   0 60   0 80   1 00
              TIME [sec]
              × 10^-6

MAGNITUDE [/Hz]
E-3 0
1 4 0
E-5 0
E-6 0
E-7 0
E 8 0
E6 0

E7 0   E8 0   E9 0
        FREQUENCY [Hz]

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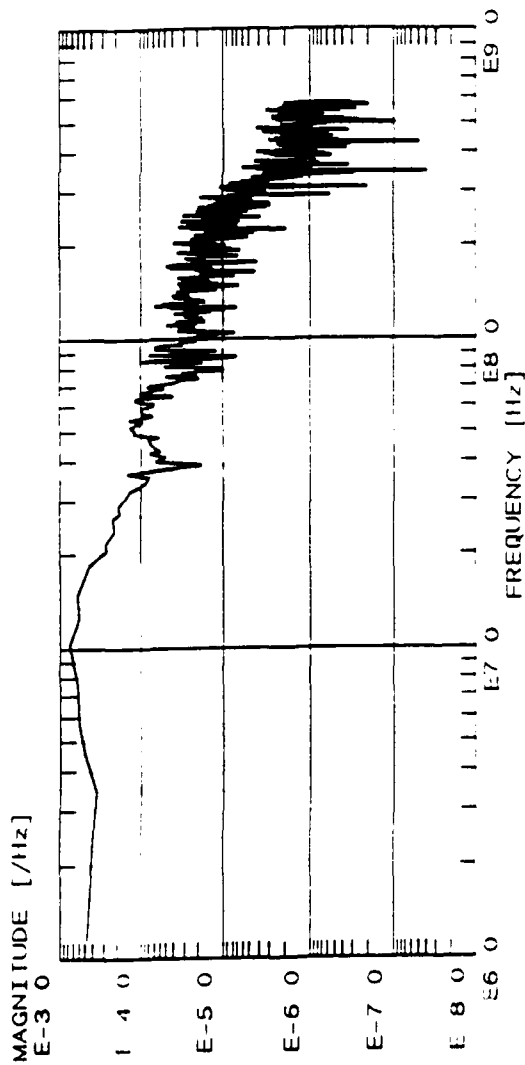
NRLOOOOO REPEAT 54, CORRECTED DATA

18-DEC-90 17 52 00   FILE DAS DATA NRLOOOOO 0054 02 1 RAW
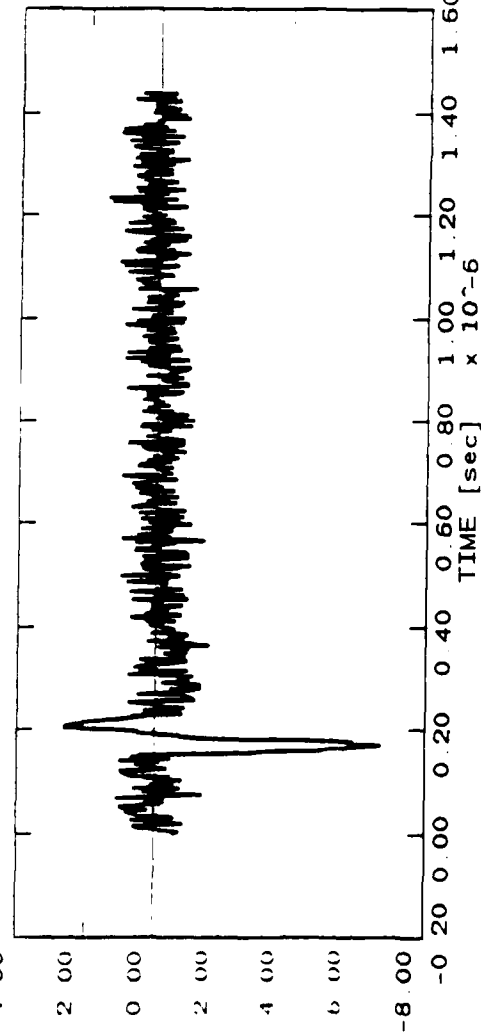
Test ID   ARC
Experiment Number   1
Pulse Number   14869
Pulse Date   30-AUG-1990 14 31 56
Quality   4
SIGNAL   Peak [V/M]   6 48 E 03
         Peak Time [sec]   0 170 E 06
         Rise Time [sec]   14 03 E 09
         Decay Time (1/e) [sec] 41 41 E 09
         Signal/Noise Ratio [dB] 20

Probe type   91550 2
Probe Eu Conv factor   0 1000000E 01

Transmitter Gain [db]   128
1 60 Total Scalar Gain [db]   28

AMPLITUDE [V/M] x 10^-3

TIME [sec] x 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
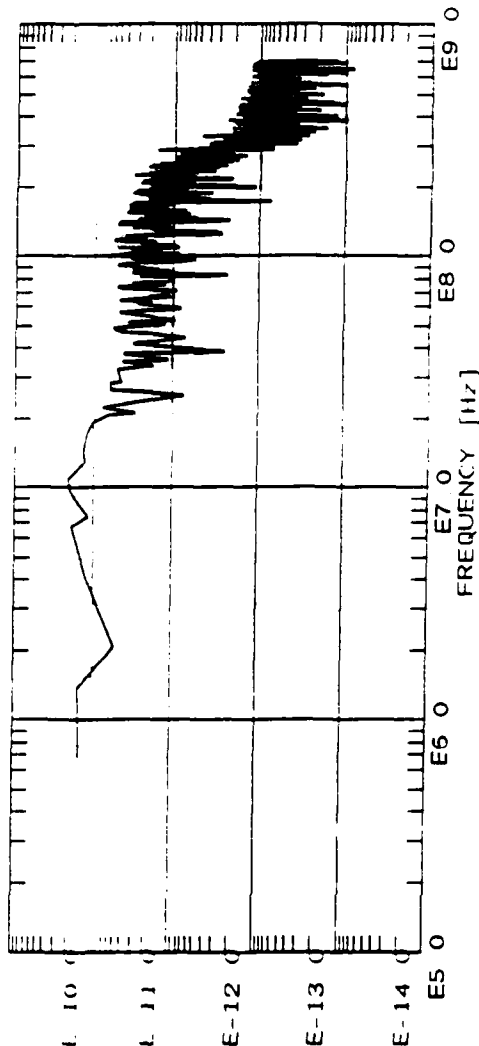
NIST0000 REPEAT 44, CORRECTED DATA

FILE: DAS DATA NIST0000 0044 04 1 RAW

18 DEC 90 16 41 55

AMPLITUDE [V/M] × 10^3

Test ID	ARC
Experiment Number	1
Pulse Number	14869
Pulse Date	30-AUG-1990 14 32 17
Quality	4
SIGNAL Peak [V/M]	83 00 E-03
Peak Time [sec]	1 340 E-06
Rise Time [sec]	0 436 E-06
Decay Time (1/e) [sec]	0 515 E-06
Signal/Noise Ratio [dB]	30
Probe type	91550 2
Probe Eu Conv factor	0 1000000E+01
Transmitter Gain [db]	+8
Total Scalar Gain [db]	8

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

DDT00000 REPEAT 58, CORRECTED DATA

Test ID   ARC
Experiment Number   1
Pulse Number   14870
Pulse Date   30-AUG-1990 14 36 28
Quality   4
SIGNAL   Peak [eu]   27 84 E+03
         Peak Time [sec]   84 36 E-09
         Rise Time [sec]   7 017 E-09
         Decay Time (1/e) [sec] 16 82 E-09
         Signal/Noise Ratio [dB] 23

Probe type   ACD-4
Probe Eu Conv factor   0 885-00001 11
Transmitter Gain [db]   11
Total Scalar Gain [db]   102

AMPLITUDE [ ]
TIME [sec] × 10^-6

MAGNITUDE [/Hz]
FREQUENCY [Hz]
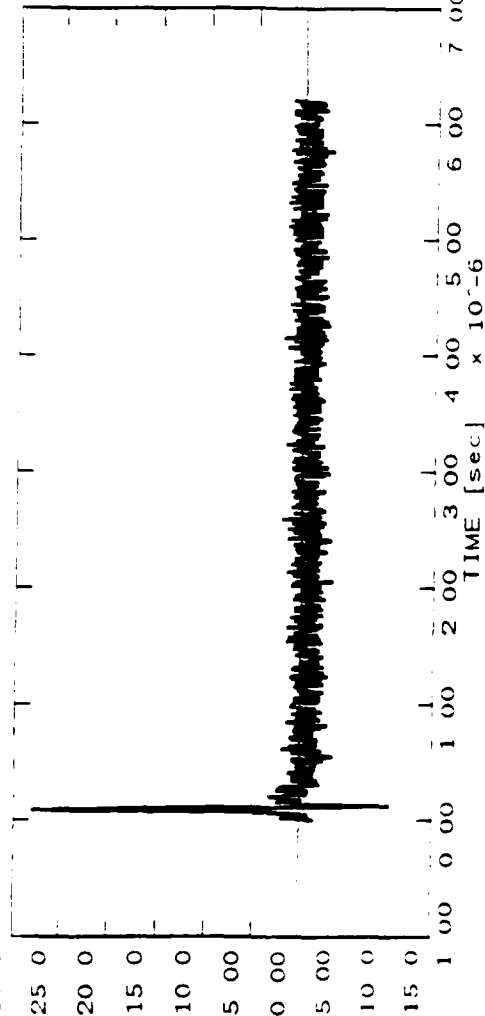
NRL00000 REPEAT 55, CORRECTED DATA

18 DEC 90 17 53 35   FILE DAS DATA NRL00000 0055 02 1 RAW
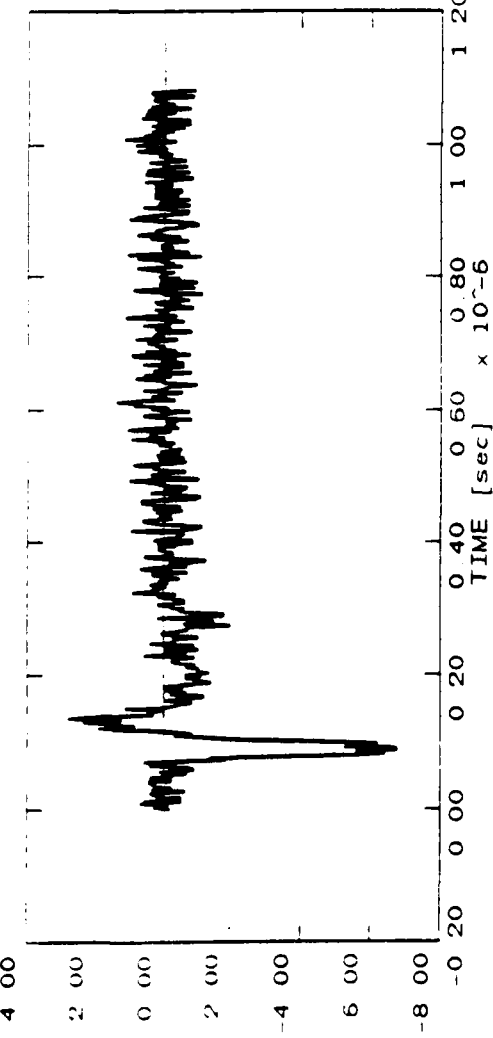
Test ID		ARC
Experiment Number		1
Pulse Number		14870
Pulse Date		30-AUG 1990 14 35 32
Quality		4
SIGNAL	Peak [V/M]	6 746 E 03
	Peak Time [sec]	90 10 E 09
	Rise Time [sec]	15 12 E 09
	Decay Time (1/e) [sec]	47 67 E 09
	Signal/Noise Ratio [dB]	24
Probe type		91550-2
Probe Eu Conv factor		0.1000000E+01
Transmitter Gain [db]		28
Total Scalar Gain [db]		28
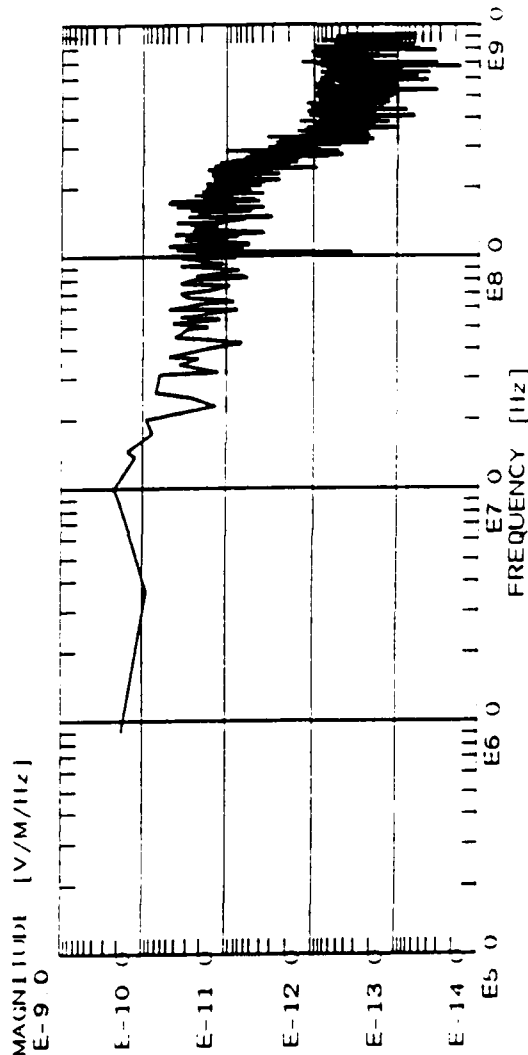
NIST0000 REPEAT 45, CORRECTED DATA

18 DEC 90   16 43 36   FILE DAS DATA NIST0000 0045 04 1 RAW
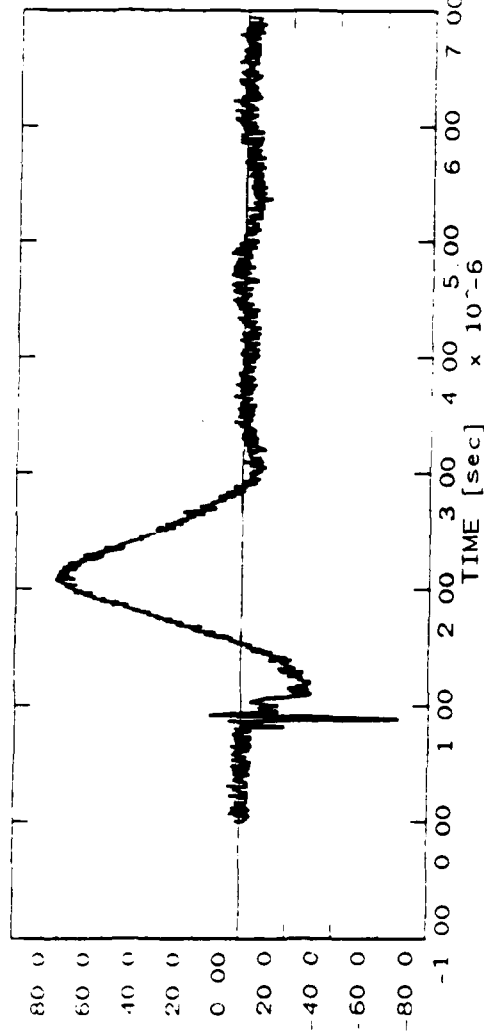
Test ID   ARC
Experiment Number   1
Pulse Number   14870
Pulse Date   30-AUG 1990 14 36 01
    Quality   4
SIGNAL   Peak [V/M]   82.51 E 03
          Peak Time [sec]   2 099 E 06
          Rise Time [sec]   0 445 E-06
          Decay Time (1/e) [sec]   0 492 E 06
          Signal/Noise Ratio [dB]   32

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01
Transmitter Gain   [db]   +8
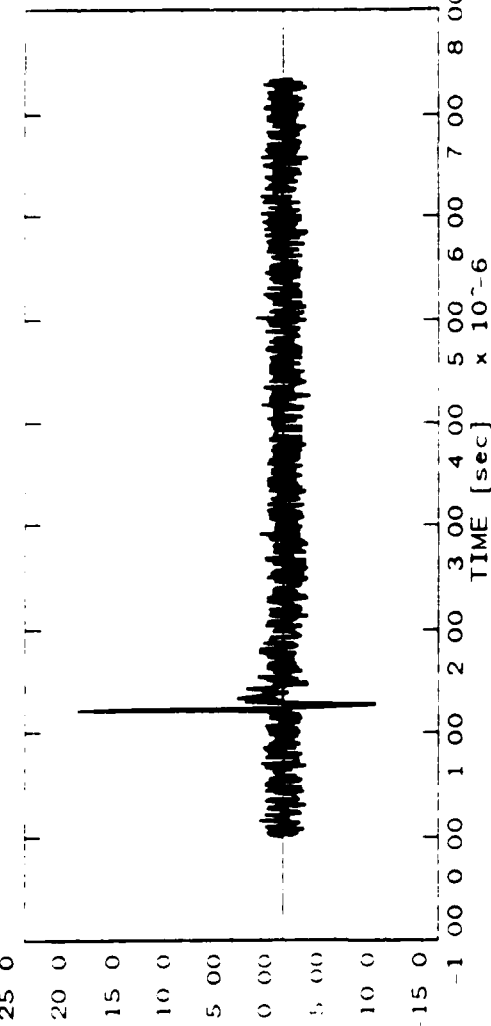Total Scalar Gain [db]   8

AMPLITUDE [V/M]   x 10^3

TIME [sec]   x 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

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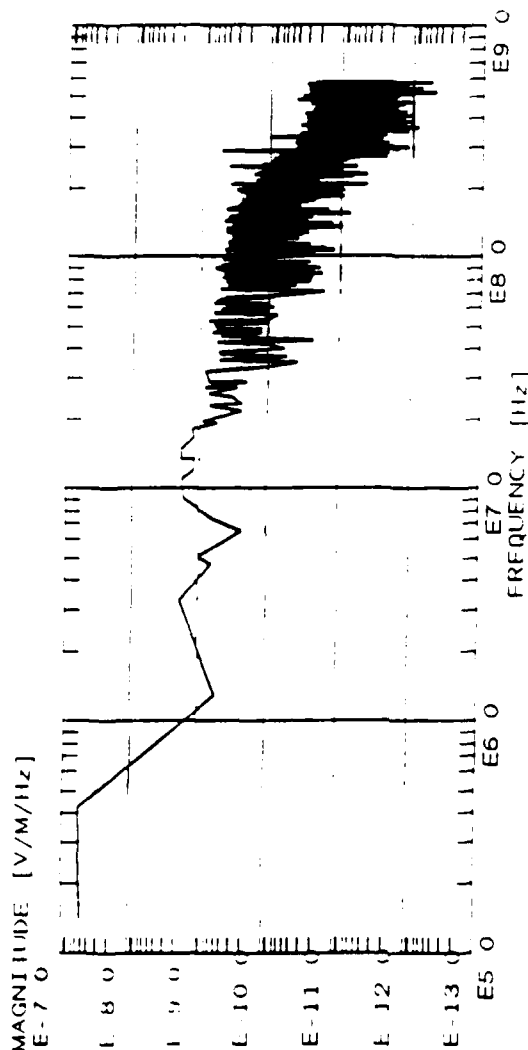
DD100000 REPEAT 59, CORRECTED DATA

18 DEC 90 15 12 30   FILE DAS DATA DD100000 0059 01 1 RAW

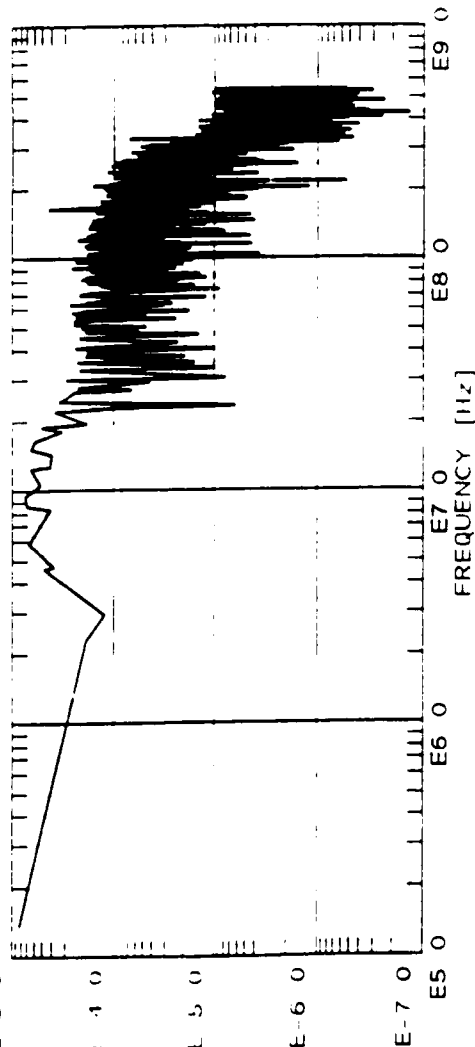Test ID   ARC
Experiment Number   1
Pulse Number   148/1
Pulse Date   30-AUG 1990 14 44 05
    Quality   6
SIGNAL Peak [eu]   20 02 E+03
        Peak Time [sec]   1 220 E-06
        Rise Time [sec]   4 831 E 09
        Decay Time (1/e) [sec]   49 78 E 09
        Signal/Noise Ratio [dB]   26

Probe type   ACD-4
Probe Eu Conv factor   0 8854000E 11
Transmitter Gain [db]   +11
Total Scalar Gain [db]   -102

AMPLITUDE [ ]   x 10^3
25 0
20 0
15 0
10 0
5 00
0 00
-5 00
-10 0
-15 0
-1 00 0 00 1 00 2 00 3 00 4 00 5 00 6 00 7 00 8 00
                                        x 10^-6
                    TIME [sec]

MAGNITUDE [/Hz]
E-3 0
1 4 0
E 5 0
E-6 0
E-7 0
E5 0   E6 0   E7 0   E8 0   E9 0
            FREQUENCY [Hz]

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NRL00000 REPEAT 56, CORRECTED DATA

AMPLITUDE [V M] × 10^5

4.00

2.00

0.00

-2.00

-4.00
-1.00 0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 8.00
TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]
E-9.0

E-10.0

E-11.0

E-12.0

E-13.0

E-14.0

E-15.0
E5.0   E6.0   E7.0   E8.0   E9.0
FREQUENCY [Hz]

NISTOOOO REPEAT 46, CORRECTED DATA

FILE DAS DATA NISTO0000 0046 04 1 RAW

Test ID	ARC
Experiment Number	1
Pulse Number	14871
Pulse Date	30-AUG 1990 14 43 27
Quality	6
SIGNAL Peak [V/M]	80 05 E-03
Peak Time [sec]	1 436 E-06
Rise Time [sec]	0 447 E-06
Decay Time (1/e) [sec]	0 412 E-06
Signal/Noise Ratio [dB]	28
Probe type	91550 2
Probe Eu Conv factor	0 1000000E 01
Transmitter Gain [db]	
Total Scalar Gain [db]	7 00

AMPLITUDE [V/M] × 10^-3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

DDT00000 REPEAT 60, CORRECTED DATA

18-DEC-90 15 14 06   FILE DAS DATA DDT00000 0060 01 1 RAW
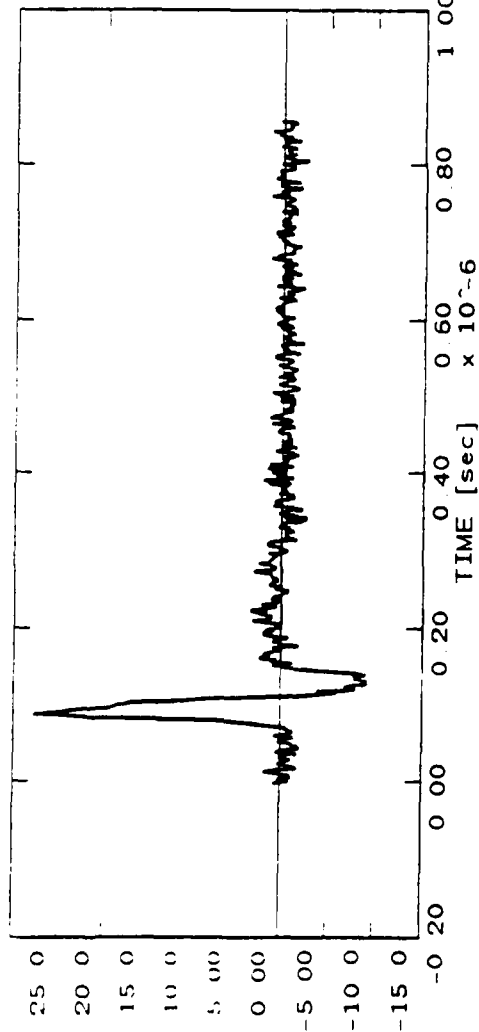
Test ID	ARC
Experiment Number	1
Pulse Number	148/2
Pulse Date	30-AUG-1990 14 46 0/
Quality	6
SIGNAL Peak [eu]	27.60 E+03
Peak Time [sec]	89.02 E-09
Rise Time [sec]	9.345 E-09
Decay Time (1/e) [sec]	1/.93 E-09
Signal/Noise Ratio [dB]	15
Probe type	ACD-4
Probe Eu Conv factor	0.8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [-]   x 10^3

TIME [sec]   x 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

NRL00000 REPEAT 57, CORRECTED DATA

18-DEC-90 17 56 58   FILE DAS DATA NRL00000 0057 02 1 RAW

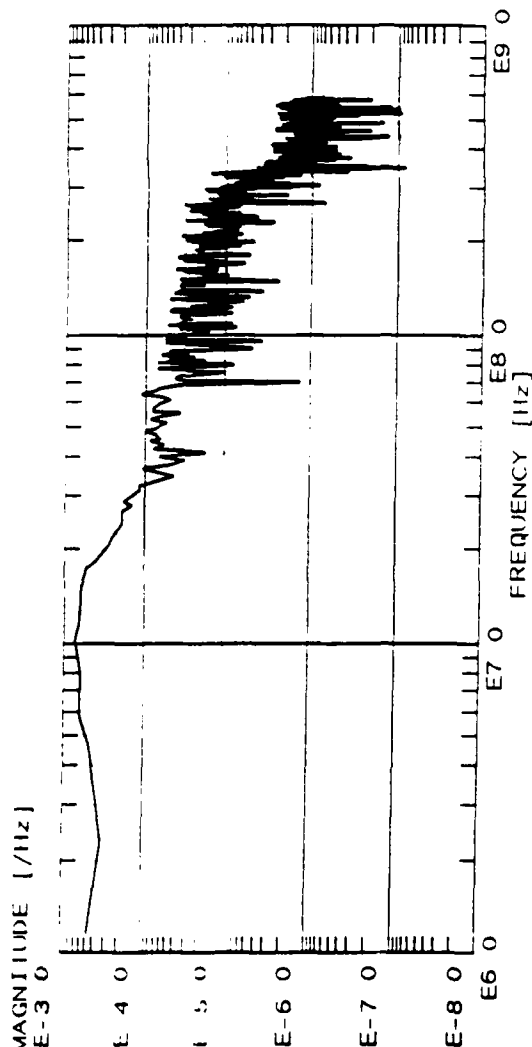Test ID   ARC
Experiment Number   1
Pulse Number   14872
Pulse Date   30-AUG 1990 14 46 50
Quality   6
SIGNAL
  Peak [V/M]   6.012 E 03
  Peak Time [sec]   1.109 E 06
  Rise Time [sec]   9.725 E-09
  Decay Time (1/e) [sec]   52.69 E-09
  Signal/Noise Ratio [dB]   20

Probe type   91550-2
Probe Eu Conv factor   0.1000000E+01

Transmitter Gain [db]   .28
Total Scalar Gain [db]   28

AMPLITUDE [V/M] $\times 10^{-3}$
TIME [sec] $\times 10^{-6}$

MAGNITUDE [V/M/Hz]
FREQUENCY [Hz]

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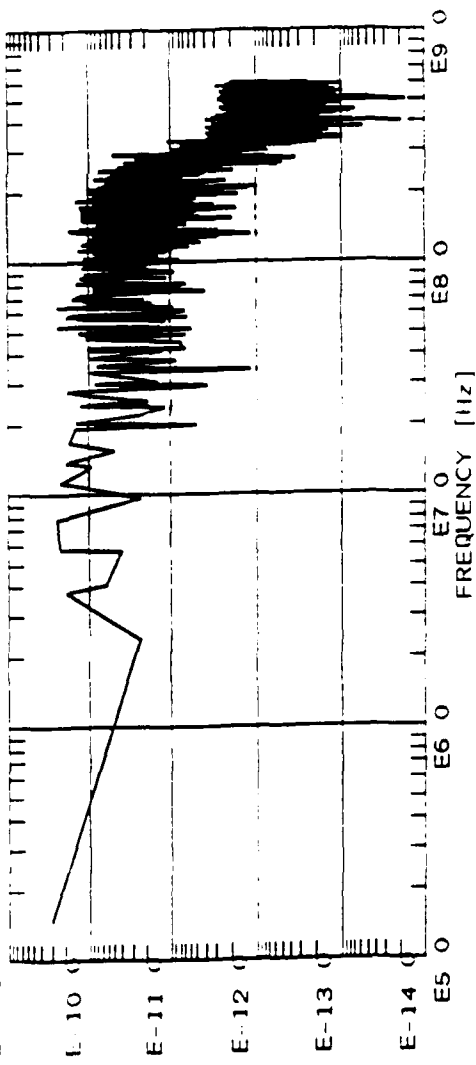
NIS10000 REPEAT 47, CORRECTED DATA

TITLE: DAG DATA NIS10000 0047/03 1 RAW
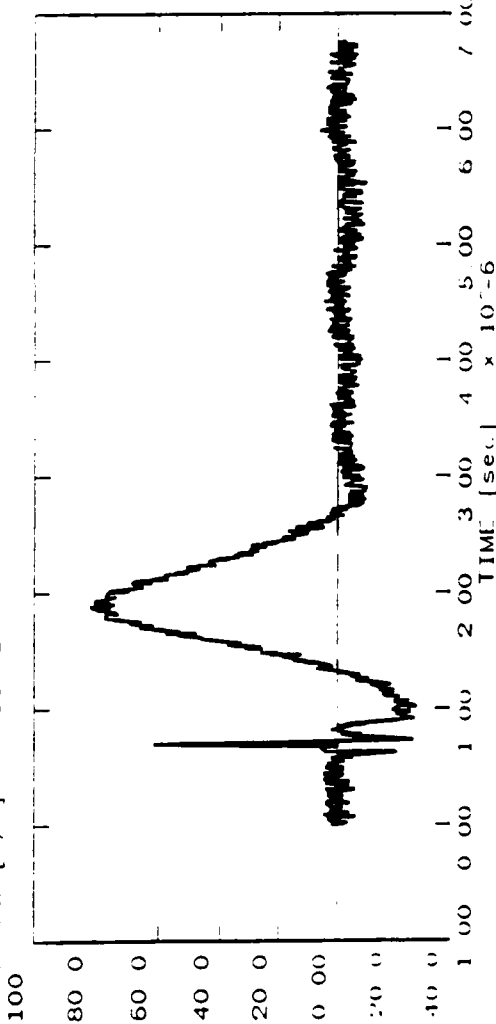
Test ID	ARC
Experiment Number	1
Pulse Number	14872
Pulse Date	30-AUG-1990 14 47 03
Quality	6
SIGNAL : Peak [V/M]	80.98 E-03
Peak Time [sec]	1.890 E-06
Rise Time [sec]	0.428 E-06
Decay Time (1/e) [sec]	0.489 E-06
Signal/Noise Ratio [dB]	30
Probe type	915502
Probe Fu Conv factor	0.100000001 01
Transmitter Gain [db]	
Total Scalar Gain [db]	

AMPLITUDE [V/M] × 10⁻3
TIME [sec] × 10⁻6

MAGNITUDE [V/M/Hz]
FREQUENCY [Hz]

DDTO0000 REPEAT 61, CORRECTED DATA

TITLE DAC DATA DDTO0000 0061 01 1 RAW

AMPLITUDE [ ] × 10^3

Test ID	ARC
Experiment Number	1
Pulse Number	14873
Pulse Date	30-AUG-1990 14 49 41
Quality	6

SIGNAL
Peak [eu] 26 87 E+03
Peak Time [sec] 87 92 E-09
Rise Time [sec] 11 47 E-09
Decay Time (1/e) [sec] 18 01 E-09
Signal/Noise Ratio [dB] 12

Probe type ACD-4
Probe Eu Conv factor 0 8854000E-11

Transmitter Gain [db] +11
Total Scalar Gain [db] -102

TIME [sec]

FREQUENCY [Hz]

MAGNITUDE [/Hz]

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NRLO0000 REPEAT 58, CORRECTED DATA

FILE. DAS DATA NRLO0000 0058 02 1 RAW

18-DEC-90 17 58 39

Test ID   ARC
Experiment Number   1
Pulse Number   148/3
Pulse Date   30-AUG-1990 14 48 5/
Quality   6
SIGNAL Peak [V/M]   6 069 E 03
        Peak Time [sec]   1 524 E-06
        Rise Time [sec]   8 004 E-09
        Decay Time (1/e) [sec]   17 62 E-09
        Signal/Noise Ratio [dB]   19

Probe type   91550-2
Probe Eu Conv factor   0.1000000E+01
Transmitter Gain [db]   ,28
Total Scalar Gain [db]   28

AMPLITUDE [V/M] x 10 3

TIME [sec] x 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

NIST0000 REPEAT 48, CORRECTED DATA

18-DEC-90 16 48 39   FILE DAS DATA NIST0000 0048 04 1 RAW
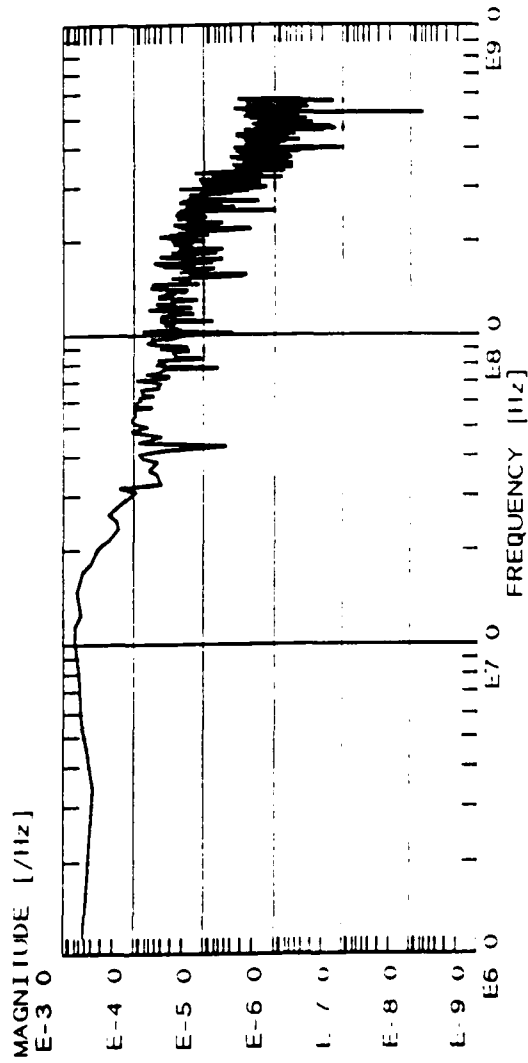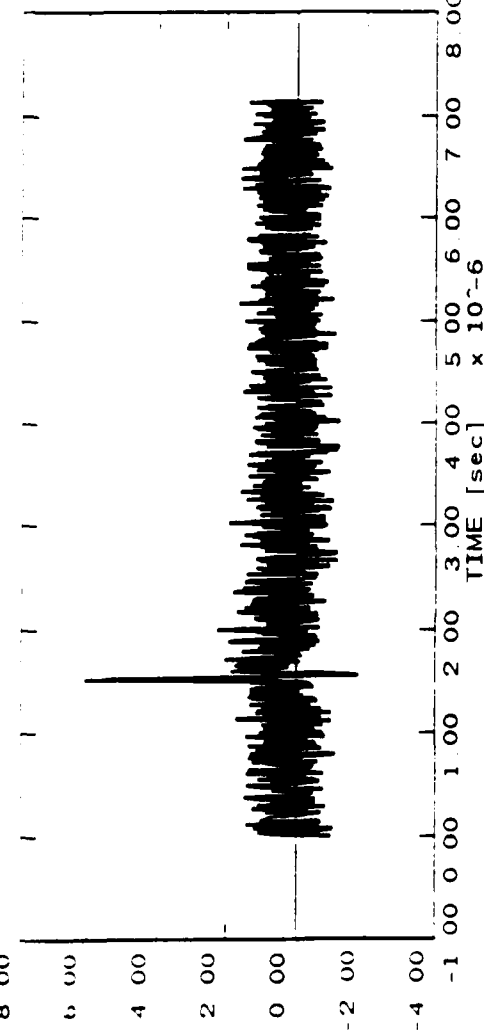
AMPLITUDE [V/M]   × 10^-3
100

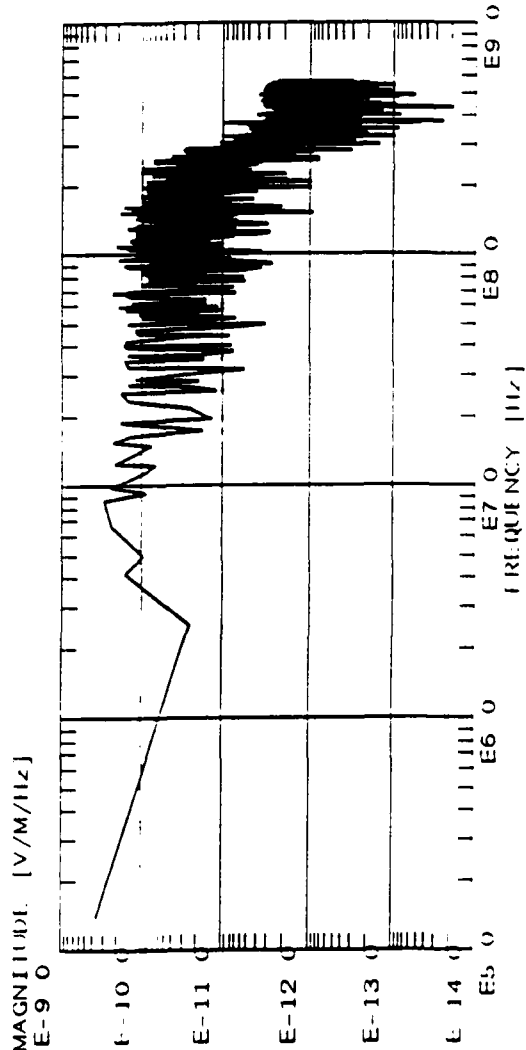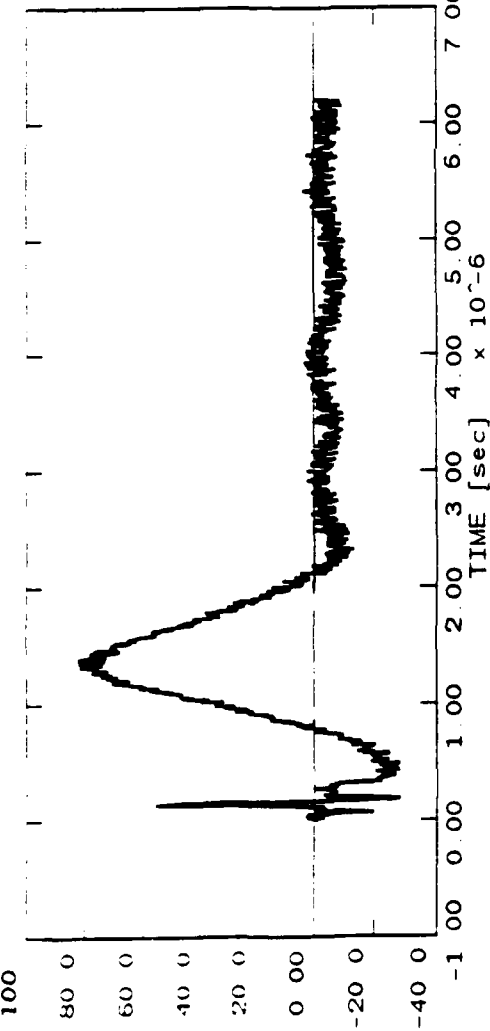Test ID   ARC
Experiment Number   1
Pulse Number   14873
Pulse Date   30-AUG-1990 14 49 19
   Quality   6
SIGNAL   Peak [V/M]   81 98 E 03
          Peak Time [sec]   1 366 E 06
          Rise Time [sec]   0 433 E-06
          Decay Time (1/e) [sec]   0 457 E 06
          Signal/Noise Ratio [dB]   26

Probe type   91550-2
Probe Eu Conv factor   0.1000000E+01

Transmitter Gain [db]   +8
7 00 Total Scalar Gain [db]   8

MAGNITUDE [V/M/Hz]

D-99
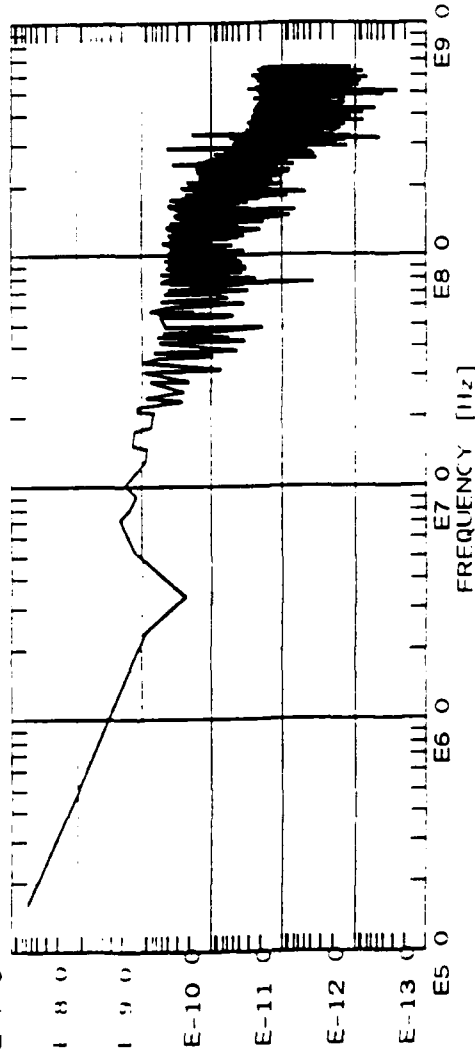
DDT00000 REPEAT 62, CORRECTED DATA

IHT DR. DAG DATA DDT00000 0062 01 1 RAW
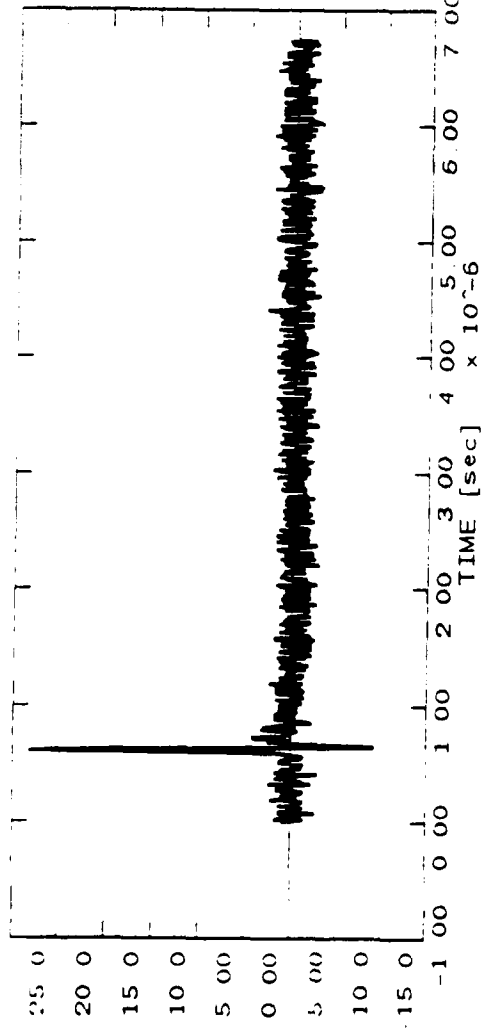
Test ID	ARC	
Experiment Number	1	
Pulse Number	14874	
Pulse Date	30-AUG-1990 14 53 09	
Quality	6	
SIGNAL: Peak [eu]	28 13 E+03	
Peak Time [sec]	0 613 E-06	
Rise Time [sec]	7 330 E-09	
Decay Time (1/e) [sec]	1/ 65 E 09	
Signal/Noise Ratio [dB]	29	
Probe type	ACD-4	
Probe Eu Conv factor	0 8854000E-11	
Transmitter Gain [db]	+11	
Total Scalar Gain [db]	-102	

AMPLITUDE [ ] × 10 3

TIME [sec] × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

NRL00000 REPEAT 59, CORRECTED DATA

Test ID   ARC
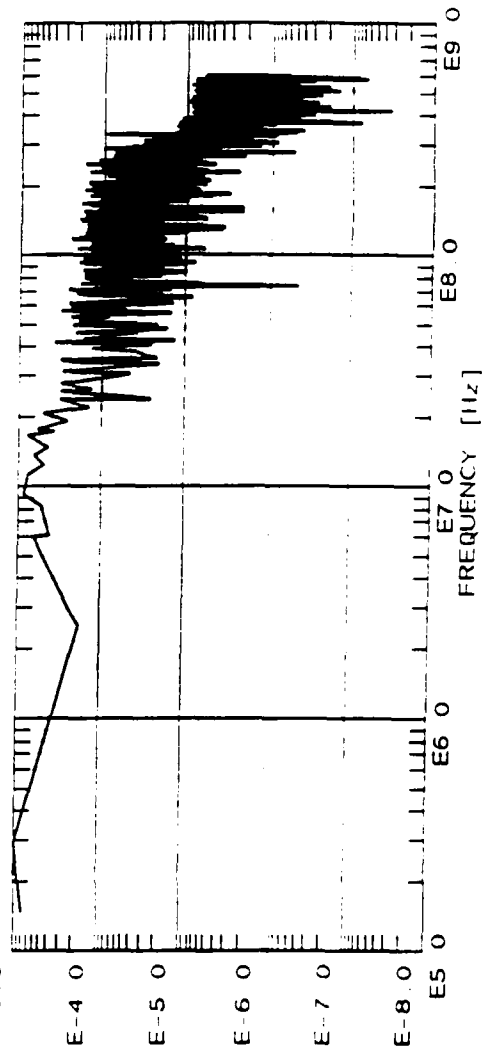Experiment Number   1
Pulse Number   14874
Pulse Date   30-AUG-1990 14 51 54
Quality   6
SIGNAL: Peak [V/M]   6 367 E-03
         Peak Time [sec]   0 411 E-06
         Rise Time [sec]   18 60 E-09
         Decay Time (1/e) [sec]   30 53 E-09
         Signal/Noise Ratio [dB]   20

Probe type   915502
Probe Eu Conv factor   0 1000000E+01
Transmitter Gain [db]   128
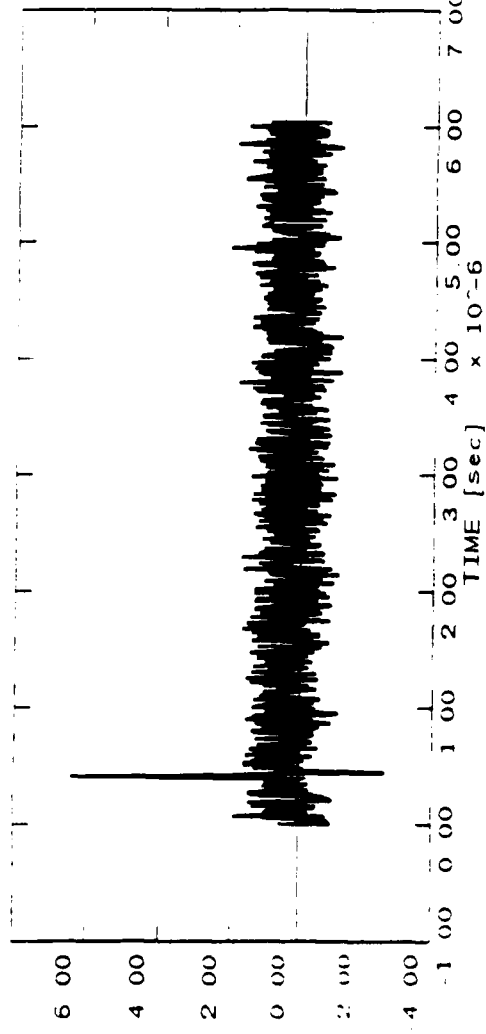Total Scalar Gain [db]   28

AMPLITUDE [V/M]   × 10^3

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-101
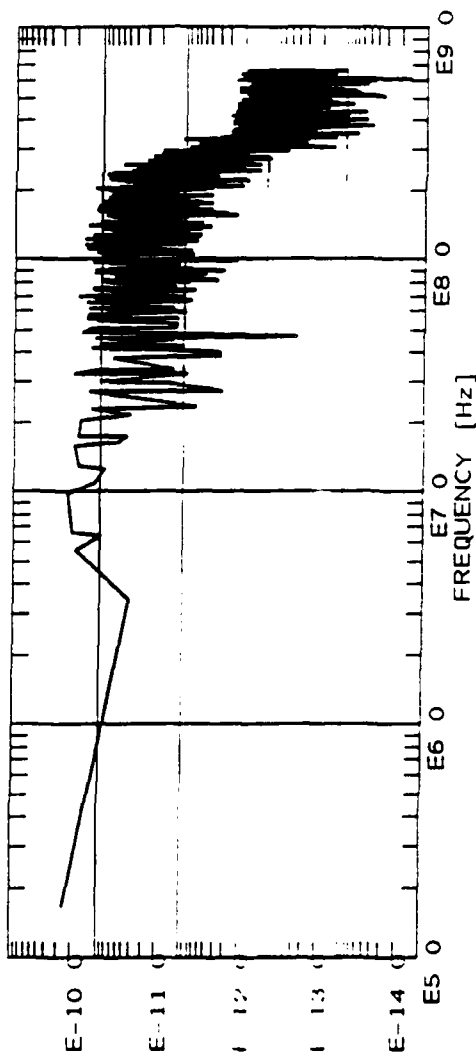
NIST0000 REPEAT 49, CORRECTED DATA

18-DEC 90 16 50 20   FILE DAS DATA NISI0000 0049 04 1 RAW
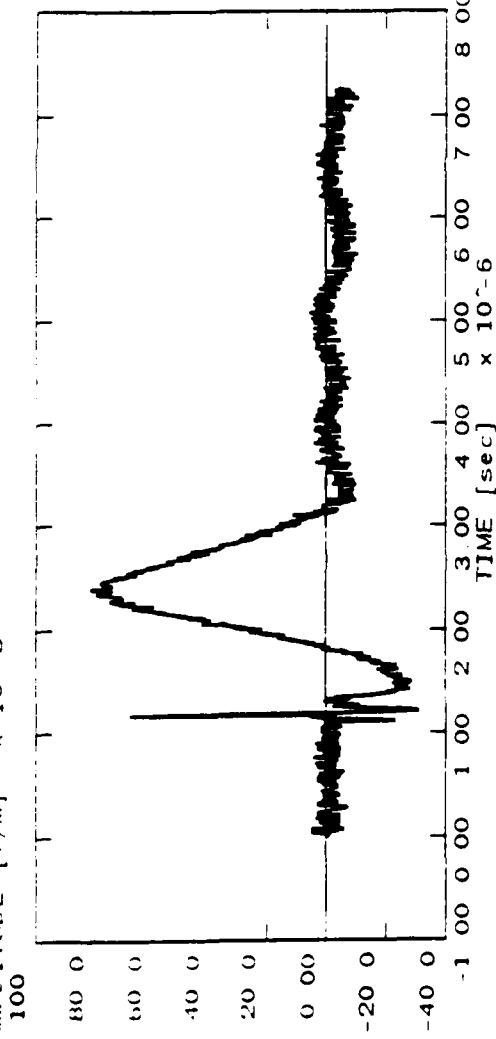
AMPLITUDE [V/M] × 10^-3

Test ID   ARC
Experiment Number   1
Pulse Number   14874
Pulse Date   30-AUG 1990 14 52 35
  Quality   6
SIGNAL Peak [V/M]   81 111 1 03
        Peak Time [sec]   2 414 E 06
        Rise Time [sec]   0 444 E 06
        Decay Time (1/e) [sec] 0 447 E 06
        Signal/Noise Ratio [dB] 30

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

Transmitter Gain [db]   +8
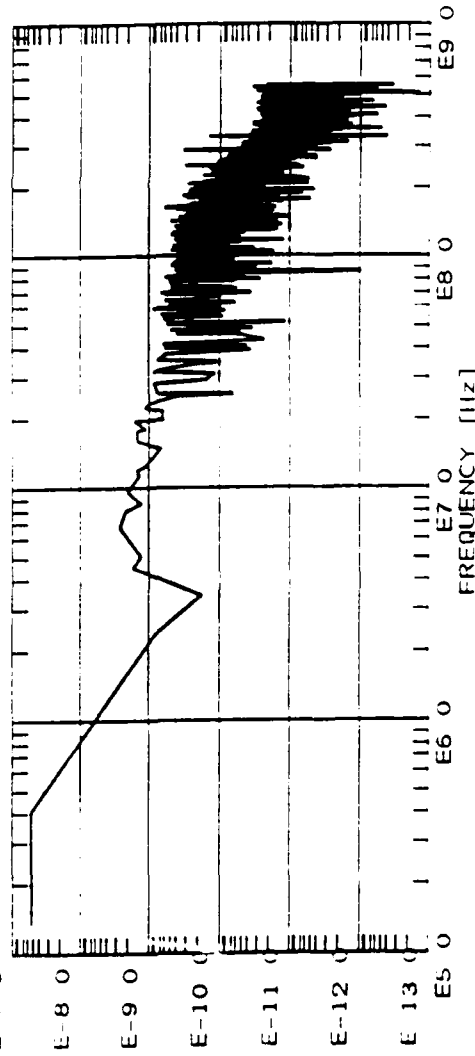Total Scalar Gain [db]   8

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

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DDT000000 REPEAT 63, CORRECTED DATA

18 DEC 90 15 19 03   FILE DAS DATA DDT000000 0063 01 1 RAW
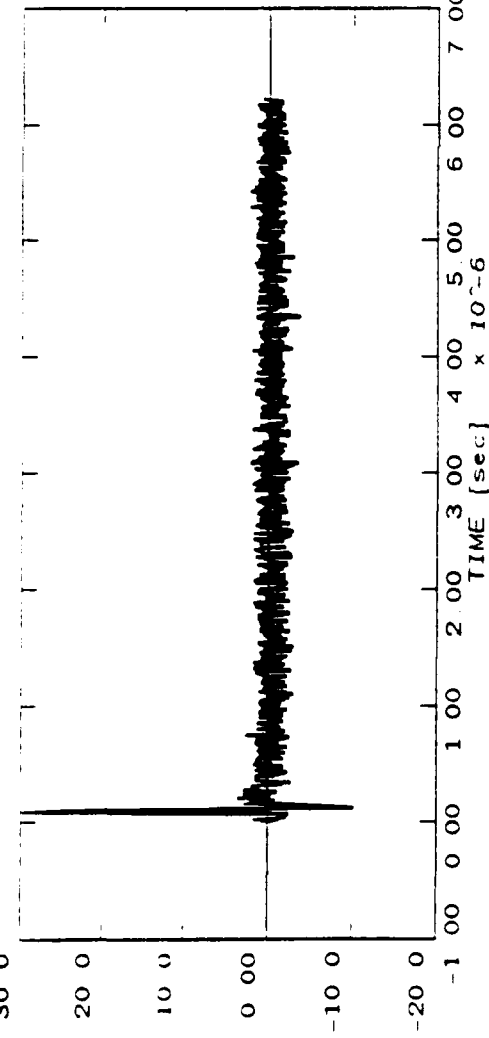
Test ID	ARC
Experiment Number	1
Pulse Number	14875
Pulse Date	30-AUG 1990 14 56 37
Quality	6
SIGNAL Peak [eu]	29 50 E+03
Peak Time [sec]	87 56 E-09
Rise Time [sec]	8 685 E-09
Decay Time (1/e) [sec]	18 58 E-09
Signal/Noise Ratio [dB]	27
Probe type	ACD-4
Probe Eu Conv factor	0 8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102
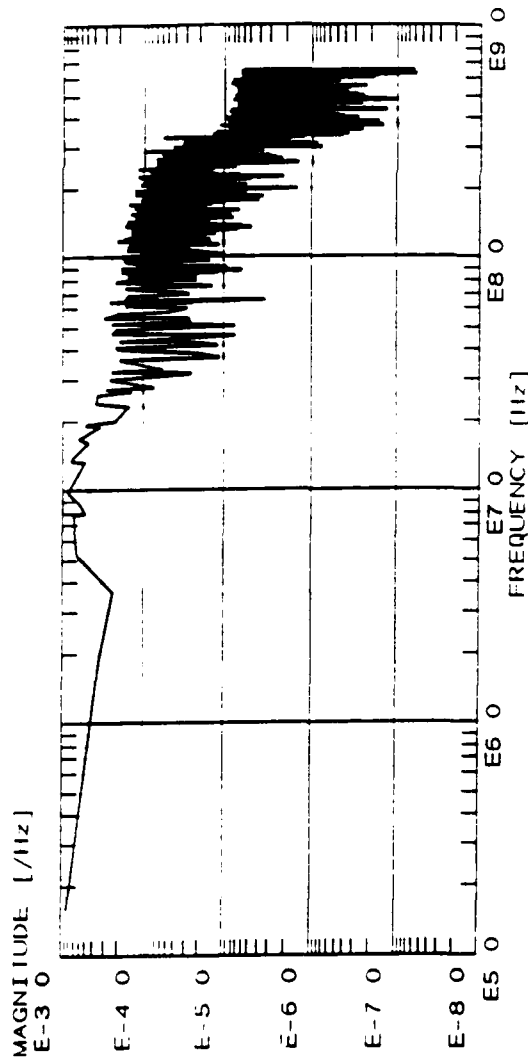
NRLO0000 REPEAT 60, CORRECTED DATA

18 DEC 90 18 02 01   FILE DATA DATA NRL 00000 00000 0060 02 1 RAW

Test ID .... ARC
Experiment Number 1
Pulse Number 14875
Pulse Date 30-AUG-1990 14 55 52
Quality 6
SIGNAL: Peak [V/M] .... 6 242 E 03
        Peak Time [sec] .... 1 688 E 06
        Rise Time [sec] .... 9 427 E 09
        Decay Time (1/e) [sec] .. 52 55 E 09
        Signal/Noise Ratio [dB] . 20

Probe type 91550 2
Probe Eu Conv factor 0 10000000 101

Transmitter Gain   [db] 28
Total Scalar Gain   [db] 28

AMPLITUDE [V/M] × 10^3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
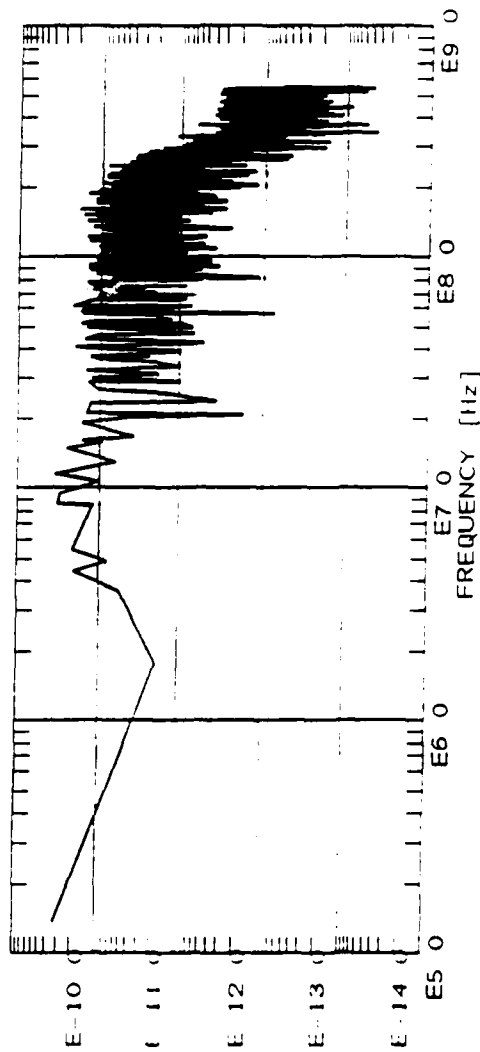
NIST0000 REPEAT 50, CORRECTED DATA

Test ID	ARC	
Experiment Number	1	
Pulse Number	14875	
Pulse Date	30-AUG 1990 14:56:16	
Quality	6	
SIGNAL Peak [V/M]		78.22 E-03
Peak Time [sec]		1.328 E-06
Rise Time [sec]		0.429 E-06
Decay Time (1/e) [sec]		0.522 E-06
Signal/Noise Ratio [dB]		27
Probe type	913550 2	
Probe Eu Conv factor	0.100000001 E01	48
Transmitter Gain [db]		
Total Scalar Gain [db]	7.00	8

AMPLITUDE [V/M] × 10-3

TIME [sec] × 10-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

DDT0OOOOO REPEAT 64, CORRECTED DATA

THE RAW DATA DDT0OOOO 0004 01 1 RAW

Test ID	ARC	
Experiment Number	1	
Pulse Number	14876	
Pulse Date	30-AUG-1990 15 00 36	
Quality	6	
SIGNAL Peak [eu]		26 45 E+03
Peak Time [sec]		86 50 E-09
Rise Time [sec]		7 466 E 09
Decay Time (1/e) [sec]		16 62 E-09
Signal/Noise Ratio [dB]		8
Probe type	ACD-4	
Probe Eu Conv factor	0 88540000E 11	
Transmitter Gain [db]	11	
1 00 Total Scalar Gain [db]	-102	

AMPLITUDE [ ] × 10^3
TIME [sec] × 10^-6

MAGNITUDE [/Hz]
FREQUENCY [Hz]

NRLOCOOO REPEAT 61, CORRECTED DATA

18-DEC 90 18 03 42

FILE DAS DATA NRL00000 0061 02 1 RAW
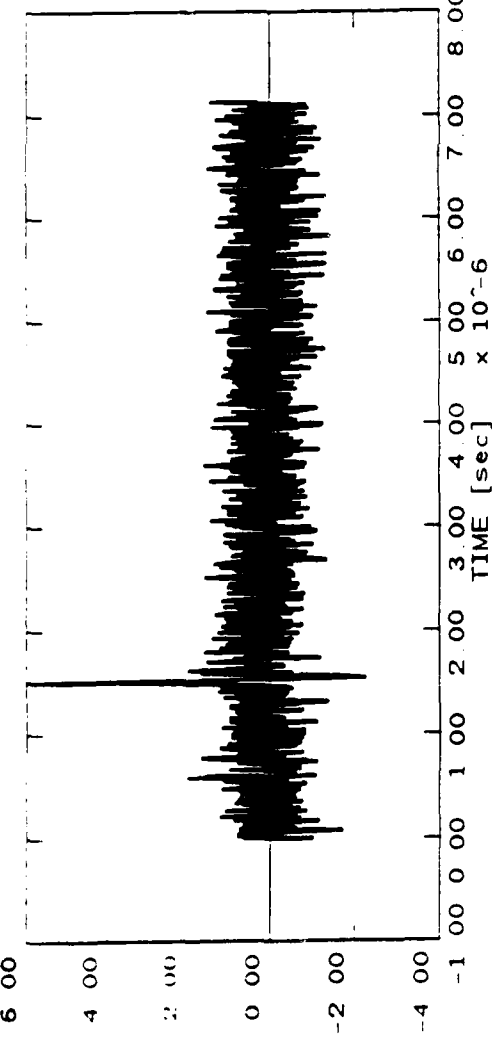
Test ID   ARC
Experiment Number   1
Pulse Number   14876
Pulse Date   30-AUG-1990 15 00 50
Quality   6
SIGNAL   5 979 E 04
Peak [V/M]   1 501 E 06
Rise Time [sec]   7 933 E-09
Decay Time (1/e) [sec]   48 93 E-09
Signal/Noise Ratio [dB]   19

Probe type   91550-2
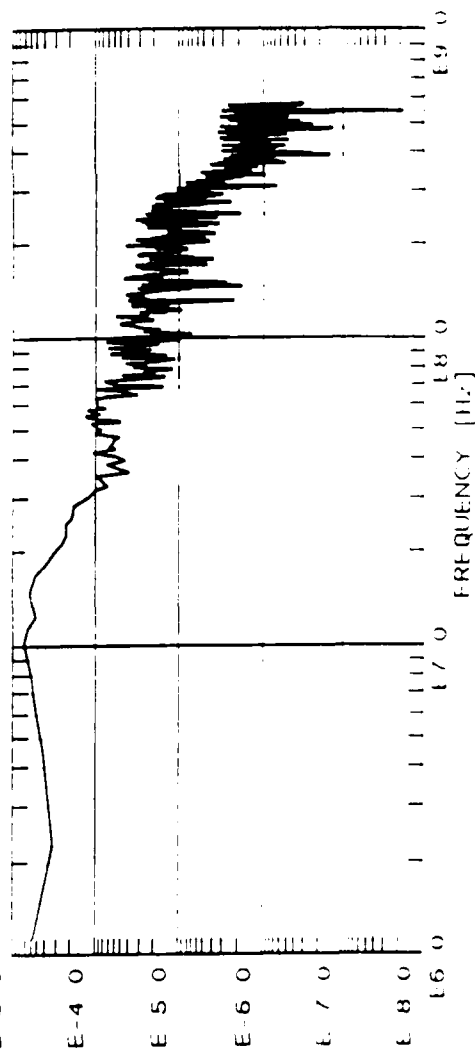Probe Eu Conv factor   0.1000000E+01

Transmitter Gain [db]   128
Total Scalar Gain [db]   28

AMPLITUDE [V/M]   × 10^-3

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
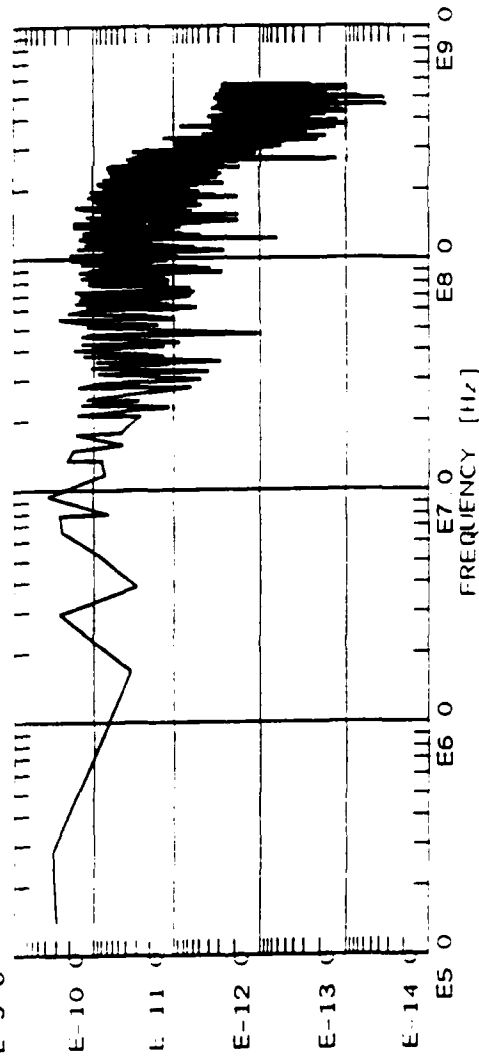
FOR OFFICIAL USE ONLY

NIS10000 REPEAT 51, CORRECTED DATA

18 DEC 90 16 53 43   FILE DAS DATA NIS10000 0051 04 1 RAW

Test ID   ARC
Experiment Number   1
Pulse Number   148/6
Pulse Date   30-AUG-1990 15 00 16
  Quality   6
SIGNAL   Peak [V/M]   80 581 03
         Peak Time [sec]   1 382 E 06
         Rise Time [sec]   0 492 E 06
         Decay Time (1/e) [sec] 0 450 E 06
         Signal/Noise Ratio [dB] 26

Probe type   91550-2
Probe Eu Conv factor   0 1000000E+01

Transmitter Gain [db]   +8
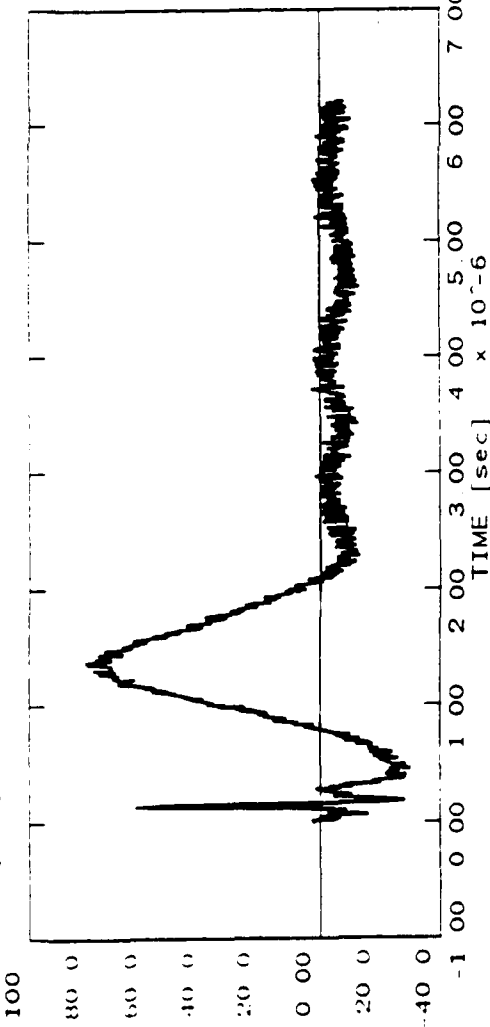Total Scalar Gain [db]   8

AMPLITUDE [V/M] × 10^3
100
80 0
60 0
40 0
20 0
0 00
20 0
-40 0
-1 00   0 00   1 00   2 00   3 00   4 00   5 00   6 00   7 00
                  TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]
E-7 0
E 8 0
E 9 0
E 10
E 11
E-12 0
E-13 0
E5 0   E6 0   E7 0   E8 0   E9 0
              FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

D-108
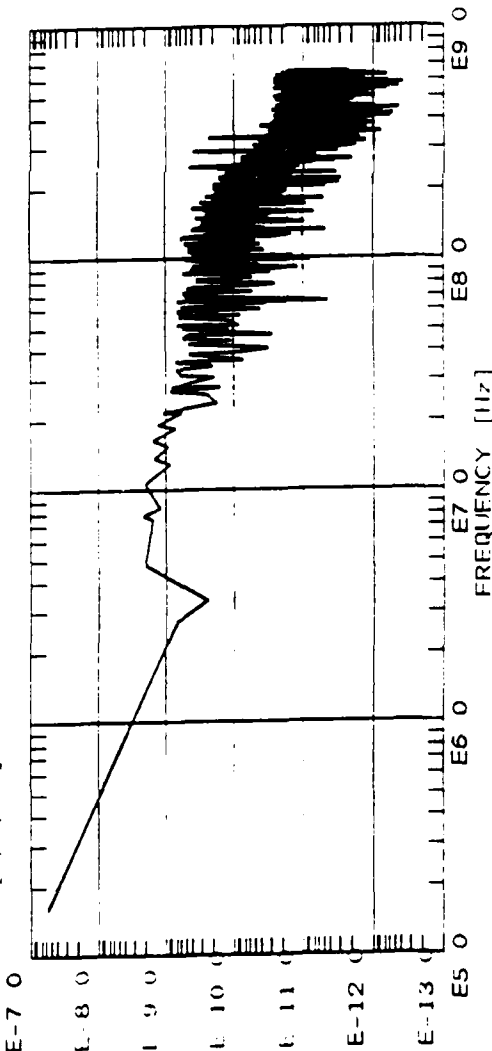
DDT00000 REPEAT 65, CORRECTED DATA

FILE DA_ DATA DDT00000 0065 01 1 RAW
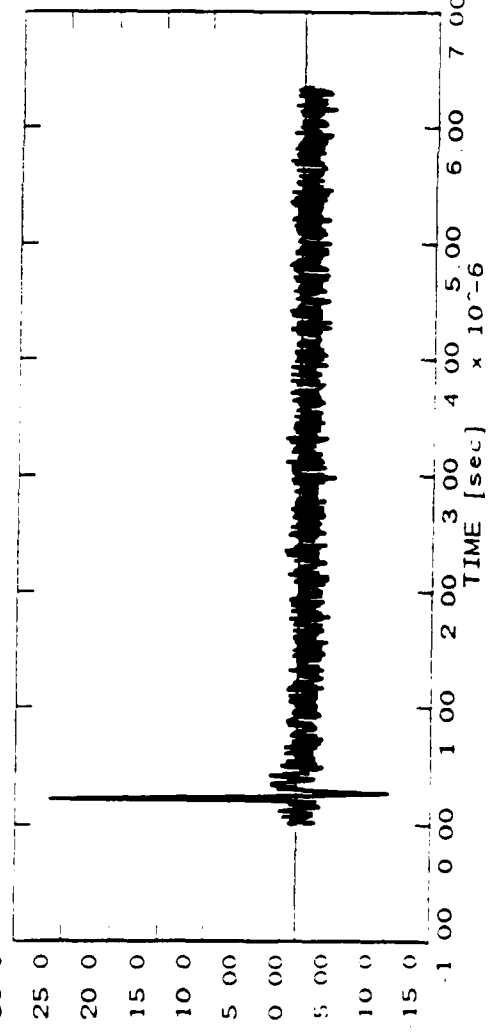
Test ID	ARC
Experiment Number	1
Pulse Number	14877
Pulse Date	30-AUG 1990 15 06 41
Quality	4
SIGNAL Peak [eu]	26 19 E+03
Peak Time [sec]	0.233 E-06
Rise Time [sec]	8 315 E-09
Decay Time (1/e) [sec]	41 29 E 09
Signal/Noise Ratio [dB]	28
Probe type	AUD 4
Probe Eu Conv factor	0 8854000E 11
Transmitter Gain [db]	111
Total Scalar Gain [db]	-102

AMPLITUDE [ ] × 10^3

TIME [sec] × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

D-109
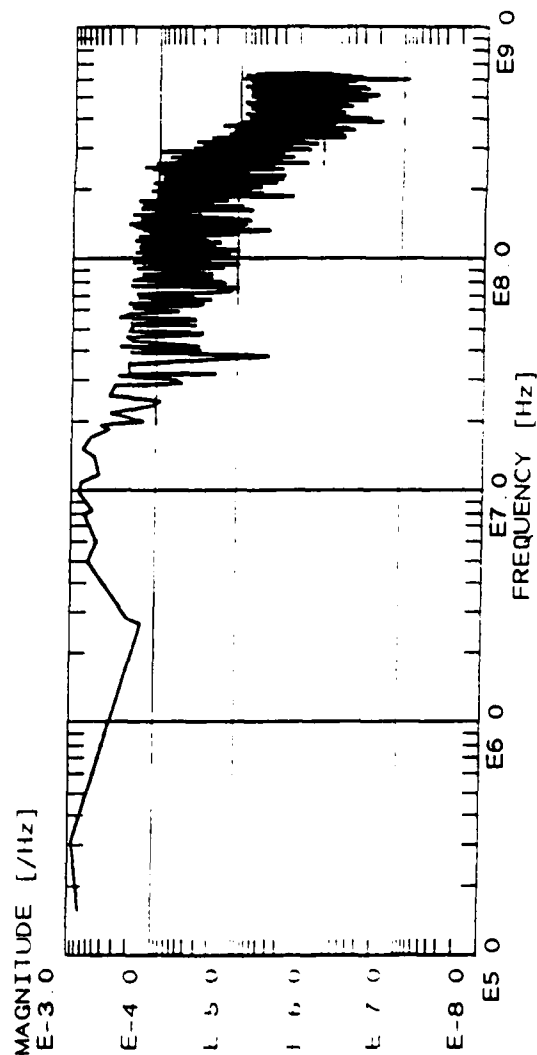
NRL00000 REPEAT 62, CORRECTED DATA

18 DEC 90 18 05 16   THE DATA DATA NRL 00000 0062 02 1 RAW

AMPLITUDE [V/M] × 10^3

Test ID	ARC
Experiment Number	1
Pulse Number	148/7
Pulse Date	30-AUG-1990 15 07 04
Quality	4
SIGNAL: Peak [V/M]	6.143 E-03
Peak Time [sec]	82.30 E-09
Rise Time [sec]	7.086 E-09
Decay Time (1/e) [sec]	47.05 E-09
Signal/Noise Ratio [dB]	8
Probe type	91550-2
Probe Eu Conv factor	0.1000000E+01
Transmitter Gain [db]	28
Total Scalar Gain [db]	28

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

FOR OFFICIAL USE ONLY

D-110
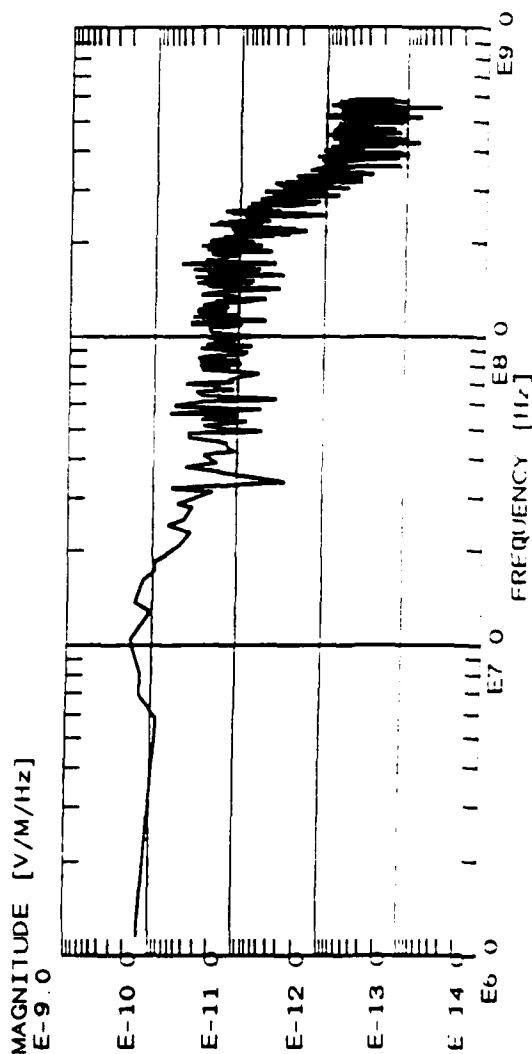
NIST0000 REPEAT 52, CORRECTED DATA

18 DEC 90 16 55 24   FILE DAS DATA NIST0000 0052 04 1 RAW
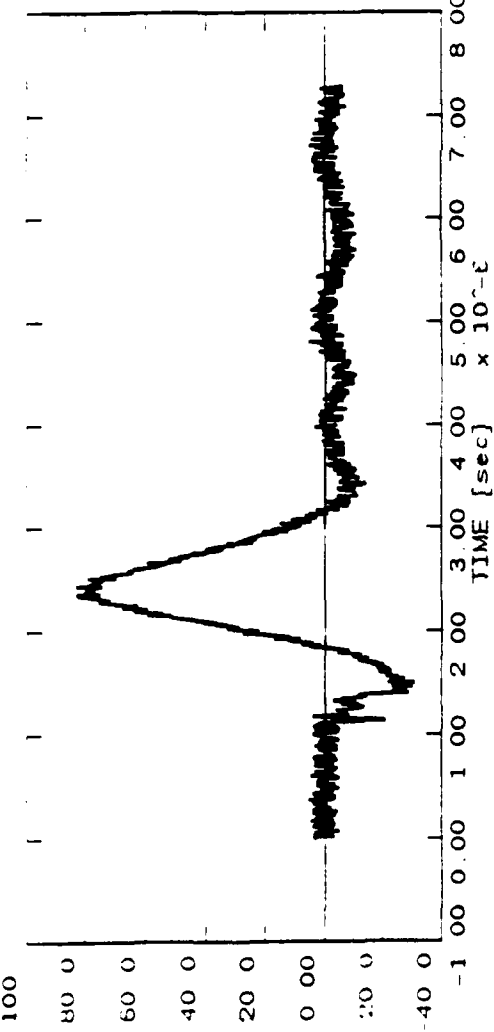
Test ID	ARC	
Experiment Number	1	
Pulse Number	1487/	
Pulse Date	30-AUG-1990 15 06 16	
Quality	4	
SIGNAL Peak [V/M]		82.48 E-03
Peak Time [sec]		2.363 E-06
Rise Time [sec]		0.400 E-06
Decay Time (1/e) [sec]		0.504 E-06
Signal/Noise Ratio [dB]		32
Probe type	91550 2	
Probe Eu Conv factor	0.1000000E+01	
Transmitter Gain [db]	+8	
Total Scalar Gain [db]	8	

AMPLITUDE [V/M] × 10^-3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
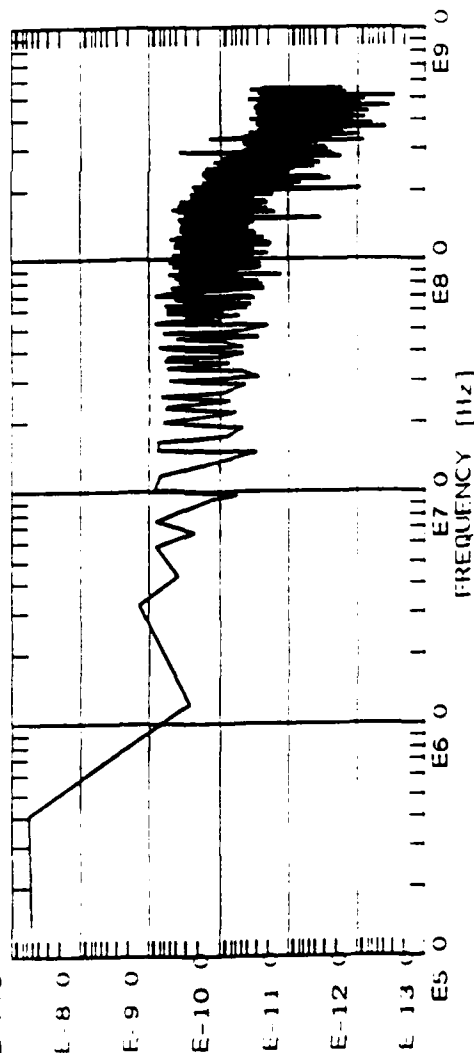
DDT00000 REPEAT 66, CORRECTED DATA

18-DEC-90 15 24:01   FILE DAS DATA DDT00000_0066_01_1 RAW
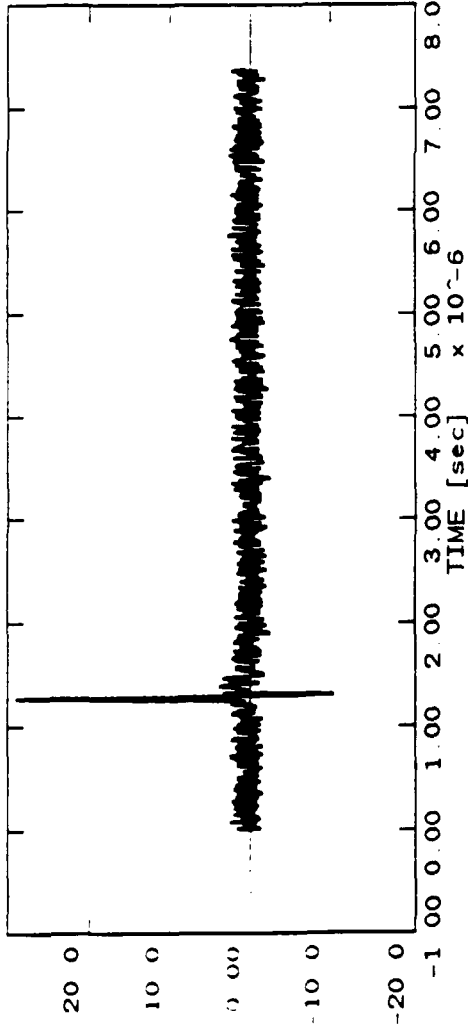
Test ID	ARC
Experiment Number	1
Pulse Number	14878
Pulse Date	30-AUG-1990 15 12 18
Quality	4
SIGNAL : Peak [eu]	28 90 E+03
Peak Time [sec]	1.273 E-06
Rise Time [sec]	8 023 E-09
Decay Time (1/e) [sec]	1/ 06 E 09
Signal/Noise Ratio [dB]	30
Probe type	ACD-4
Probe Eu Conv factor	0 8854000E-11
Transmitter Gain [db]	+11
Total Scalar Gain [db]	-102

AMPLITUDE [-] × 10^3

TIME [sec] × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]
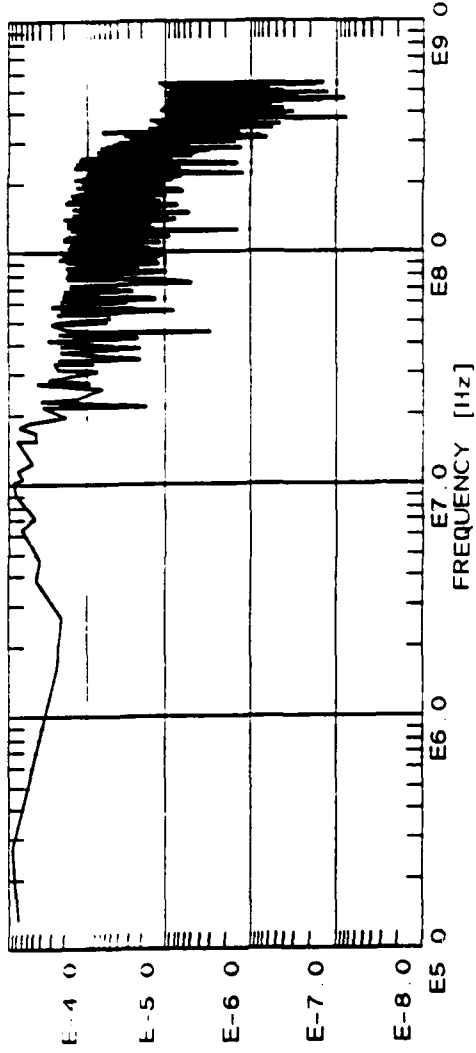
NRL00000 REPEAT 63, CORRECTED DATA

18 DEC 90 18:06:57   TITLE DAS DATA NRL 00000 0063 02 1 RAW

AMPLITUDE [V/M] × 10⁻³

Test ID	ARC
Experiment Number	1
Pulse Number	14878
Pulse Date	30-AUG-1990 15:12:40
Quality	4
SIGNAL: Peak [V/M]	6.640 E-03
Peak Time [sec]	90.82 E-09
Rise Time [sec]	13.51 E-09
Decay Time (1/e) [sec]	2.98 E-09
Signal/Noise Ratio [dB]	19
Probe type	91550-2
Probe Eu Conv factor	0.1000000E+01
Transmitter Gain [db]	28
Total Scalar Gain [db]	28

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-113
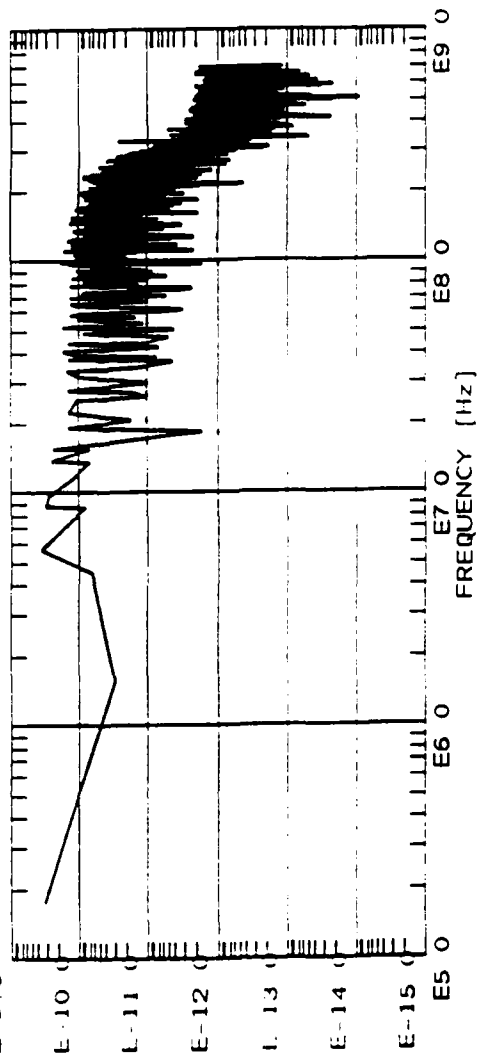
NIST0000 REPEAT 53, CORRECTED DATA

THE BAG DATA NIST00000 0053 04 1 RAW

Test ID	ARC	
Experiment Number	1	
Pulse Number	14878	
Pulse Date	30-AUG-1990 15:11:54	
Quality	4	
SIGNAL: Peak [V/M]	34.53	E-03
Peak Time [sec]	2.094	E-06
Rise Time [sec]	0.489	E-06
Decay Time (1/e) [sec]	0.478	E-06
Signal/Noise Ratio [dB]	30	
Probe type	91550 2	
Probe Eu Conv factor	0.1000000E+01	
Transmitter Gain [db]	18	
Total Scalar Gain [db]	8	

AMPLITUDE [V/M] × 10^-3

TIME [sec] × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-114
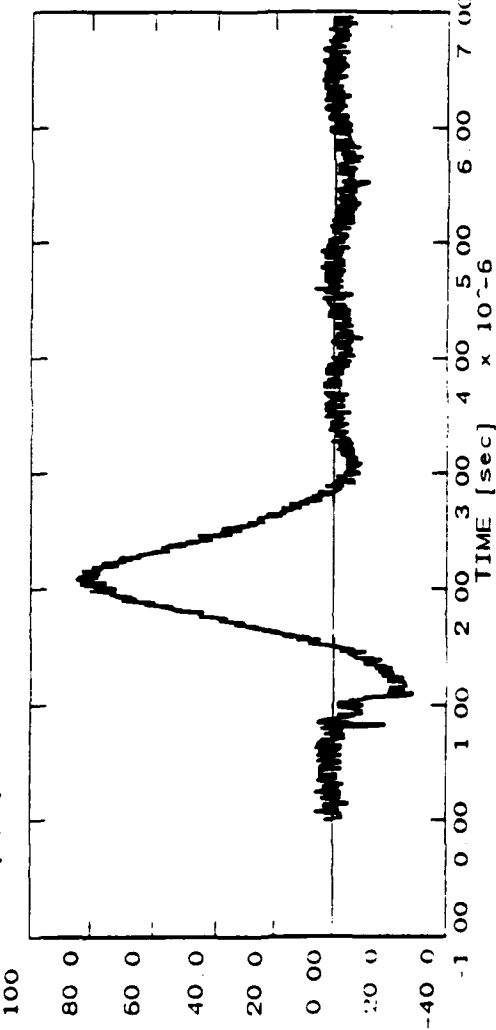
DDT00000 REPEAT 67, CORRECTED DATA

18 DEC 90   15 25 47   FILE DAS DATA DDT00000 0067 01 1 RAW
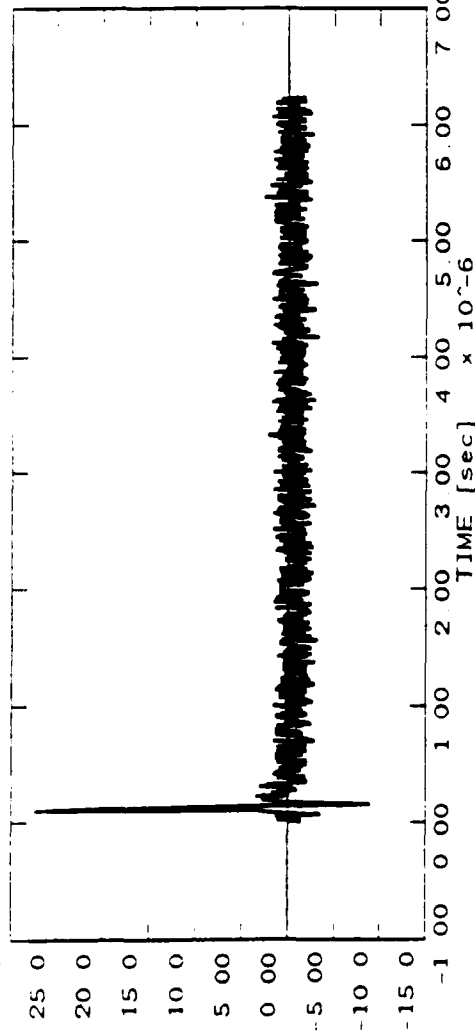
Test ID	ARC	
Experiment Number	1	
Pulse Number	14879	
Pulse Date	30-AUG-1990 15 15 49	
Quality	4	
SIGNAL: Peak [eu]		27 24 E+03
Peak Time [sec]		0 112 E-06
Rise Time [sec]		7 543 E-09
Decay Time (1/e) [sec]		17 38 E 09
Signal/Noise Ratio [dB]		27
Probe type	ACD-4	
Probe Eu Conv factor	0 8854000E-11	
Transmitter Gain [db]	+11	
Total Scalar Gain [db]	-102	

AMPLITUDE [ ] × 10^3

TIME [sec] × 10^-6

MAGNITUDE [/Hz]

FREQUENCY [Hz]

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D-115
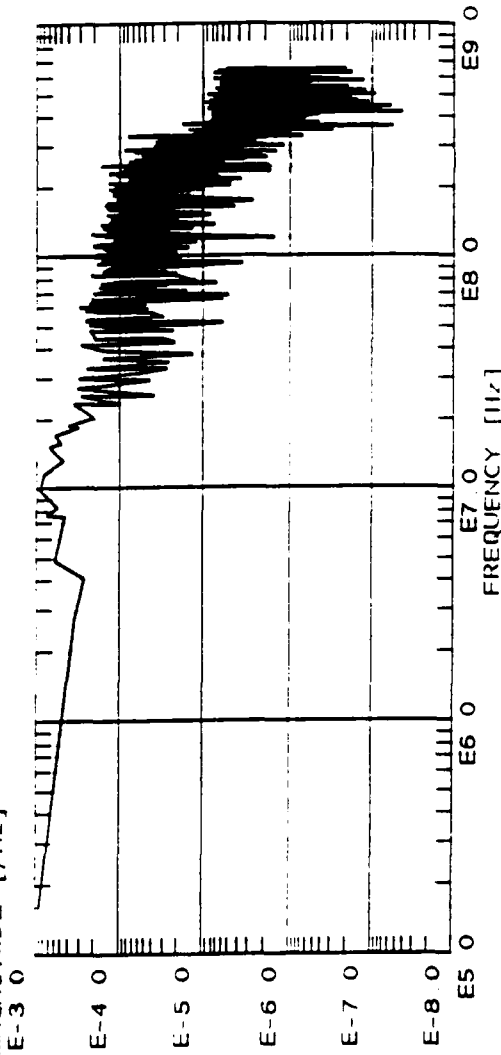
NRLO0000 REPEAT 64, CORRECTED DATA

18-DEC-90 18 08 38

FILE DAS DATA NRLO0000_0064_02_1 RAW

AMPLITUDE [V/M]   × 10^-3
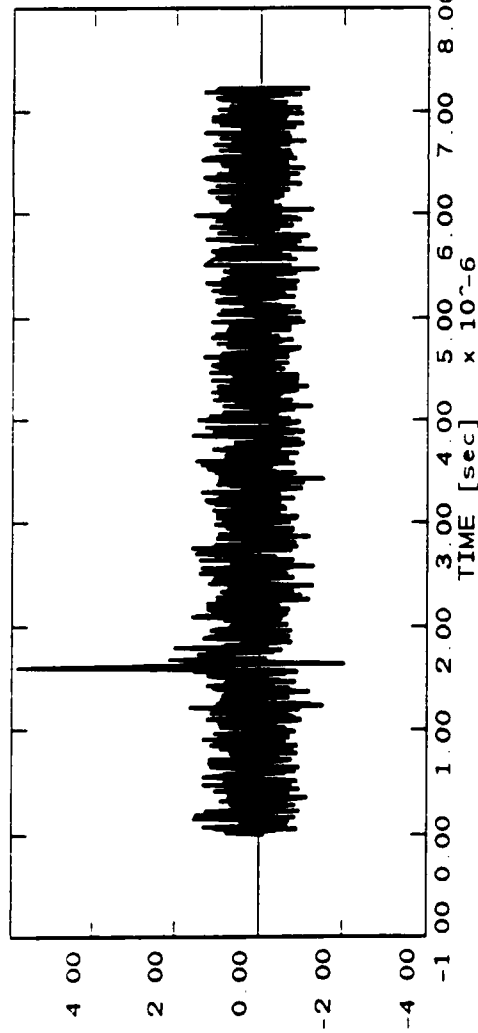
Test ID	ARC
Experiment Number	1
Pulse Number	14879
Pulse Date	30-AUG-1990 15 16 12
Quality	4
SIGNAL: Peak [V/M]	5 875 E-03
Peak Time [sec]	1 603 E-06
Rise Time [sec]	12.06 E-09
Decay Time (1/e) [sec]	75 32 E-09
Signal/Noise Ratio [dB]	20
Probe type	91550-2
Probe Eu Conv factor	0.1000000E+01
Transmitter Gain [db]	28
Total Scalar Gain [db]	28

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]
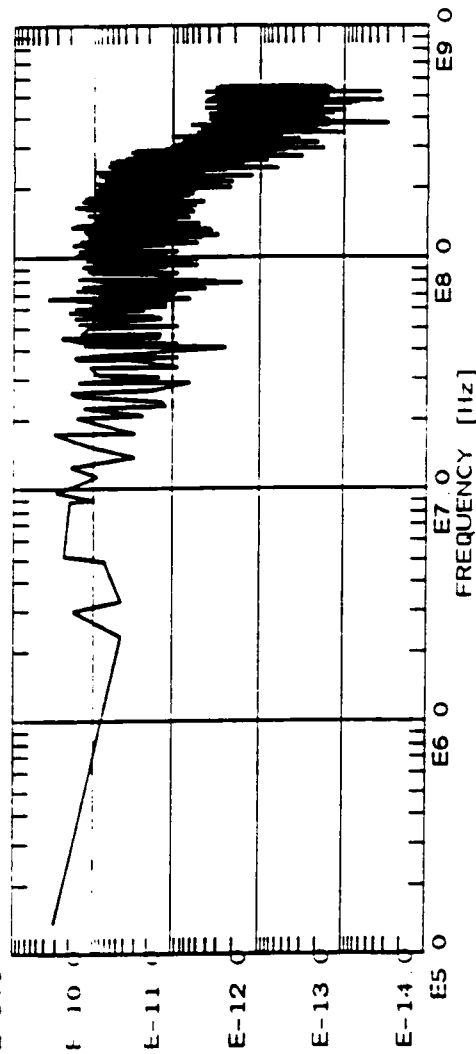
NIST0000 REPEAT 54, CORRECTED DATA

18-DEC-90   16 58 46   FILE DAS DATA NIST0000_0054_04_1 RAW

AMPLITUDE [V/M]   × 10^-3
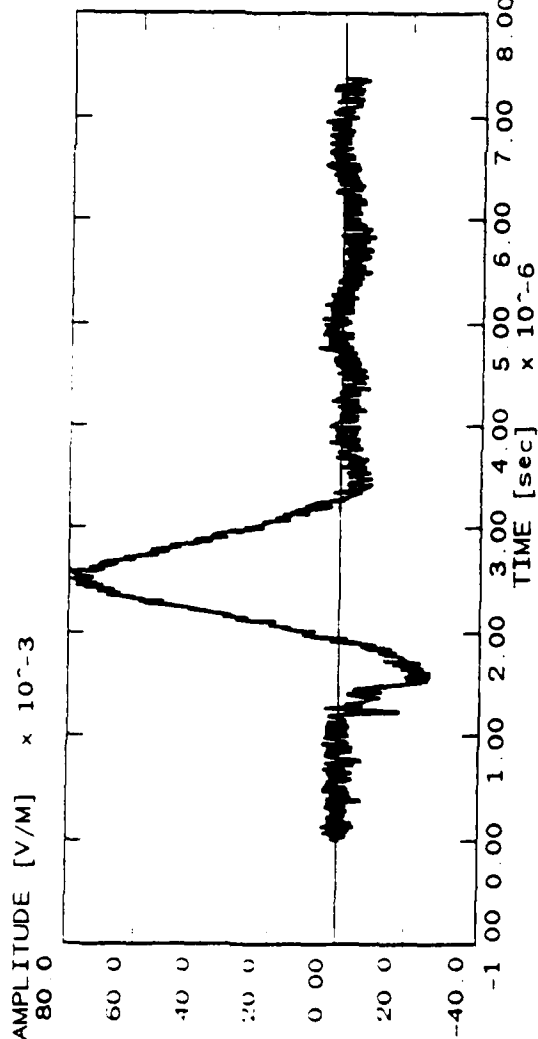
Test ID	ARC
Experiment Number	1
Pulse Number	14879
Pulse Date	30-AUG-1990 15 15 12
Quality	4
SIGNAL Peak [V/M]	79 30 E 03
Peak Time [sec]	2 589 E 06
Rise Time [sec]	C 445 E-06
Decay Time (1/e) [sec]	C 419 E-06
Signal/Noise Ratio [dB]	32
Probe type	91550-2
Probe Eu Conv. factor	0.1000000E+01
Transmitter Gain [db]	+8
Total Scalar Gain [db]	8

TIME [sec]   × 10^-6

MAGNITUDE [V/M/Hz]

FREQUENCY [Hz]

D-117
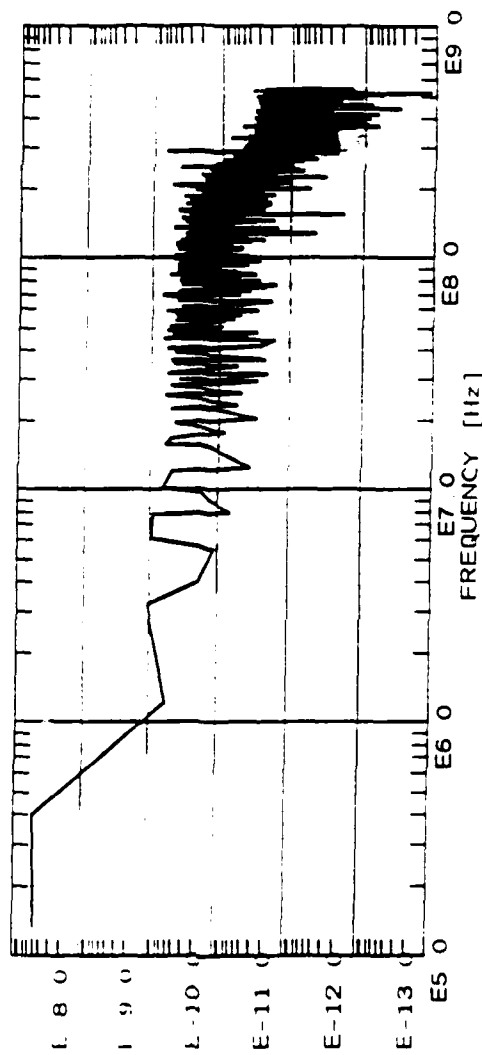
APPENDIX E

EXPANDED PEAK DATA

Analysis of the data collected from the D•Dot, NIST, and NRL sensors included the examination of pulse rise and decay times, and the effects of primary reflections from the ground plane into each sensor. An ARC-developed signal analysis software package was used to expand the time scales of the test data waveforms. This appendix presents the expanded time scale graphs. See Section 3.0 of this report for a discussion of these data.
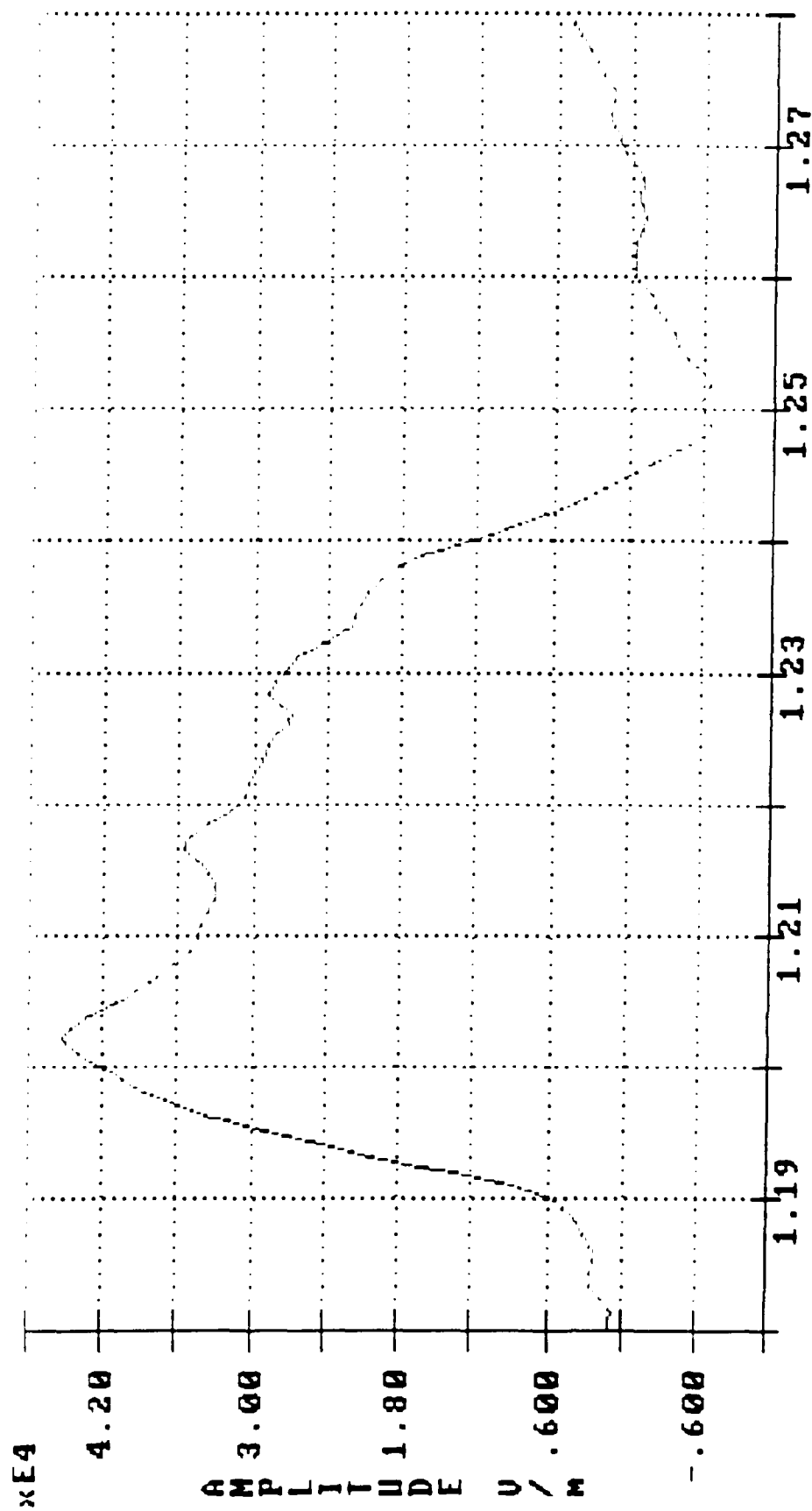
SHOT #: 14842 D-DOT PROBE 30 AUG 1990
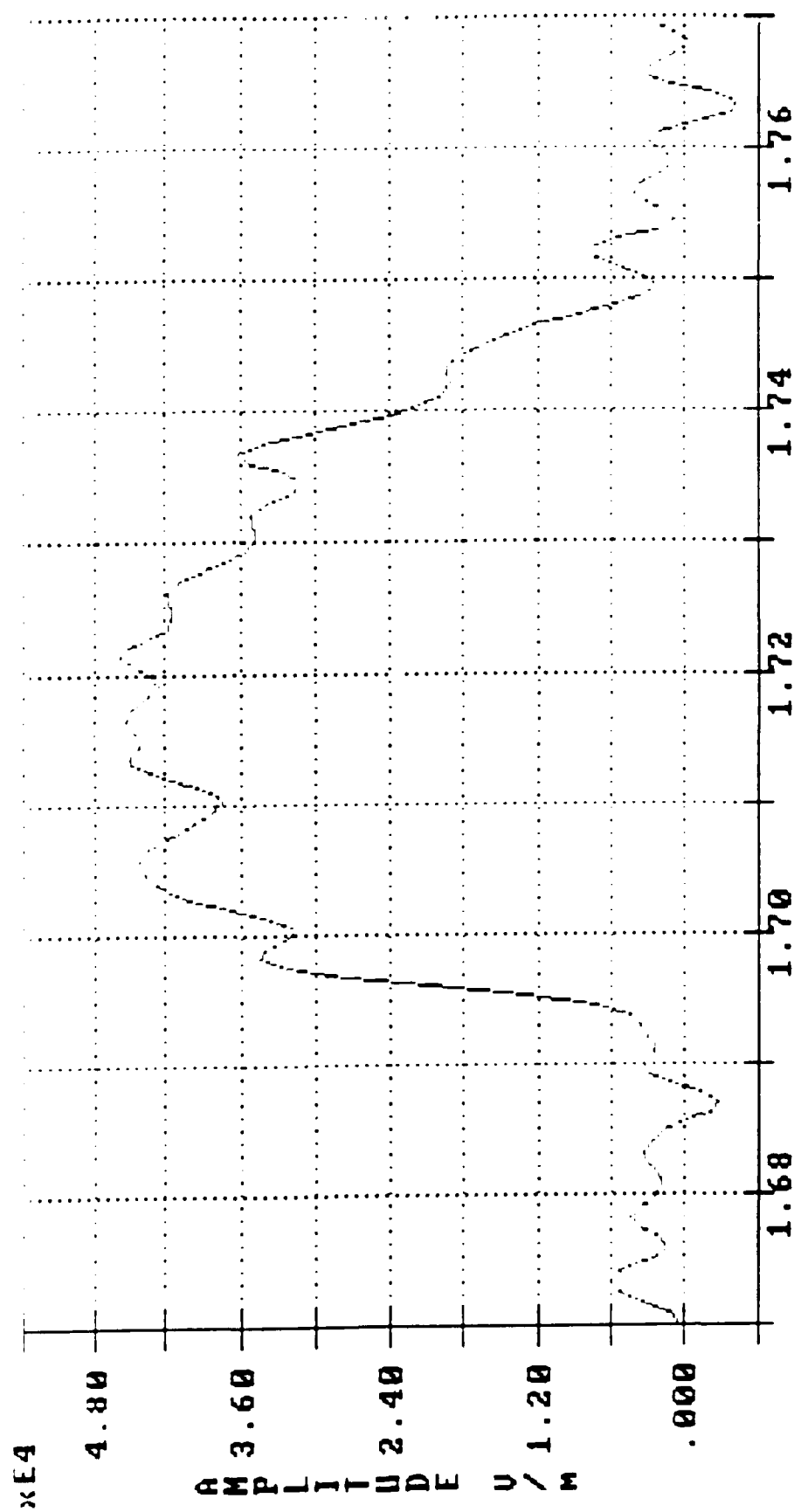
SHOT #: 14842 NRL PROBE 30 AUG 1990

E-3

xE4

AMPLITUDE V/m

4.90
3.50
2.10
.700
-.700

TIME (MICROSECONDS)

1.24   1.26   1.28   1.30   1.32
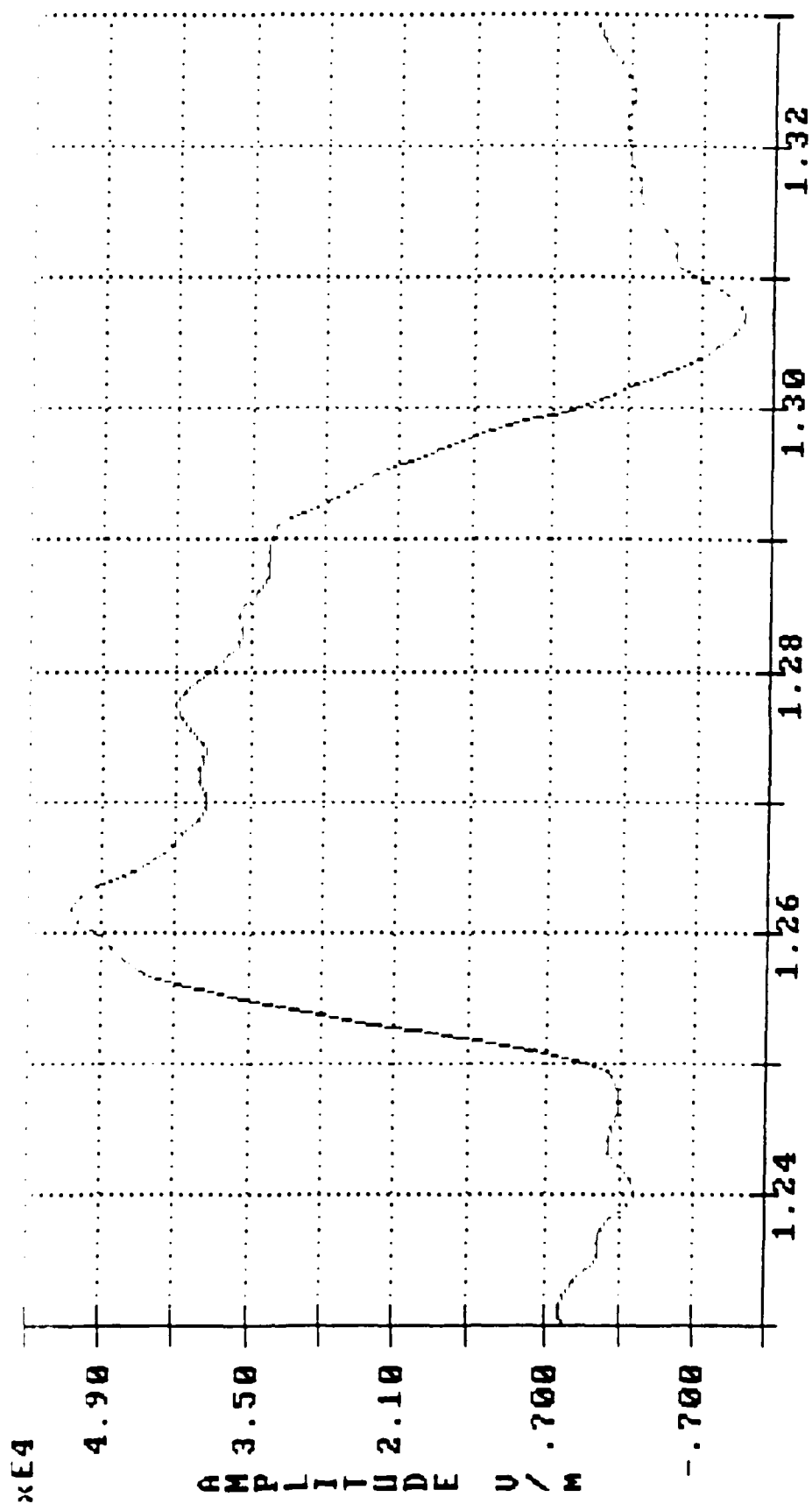
SHOT #: 14842 NIST PROBE 30 AUG 1990

E-4
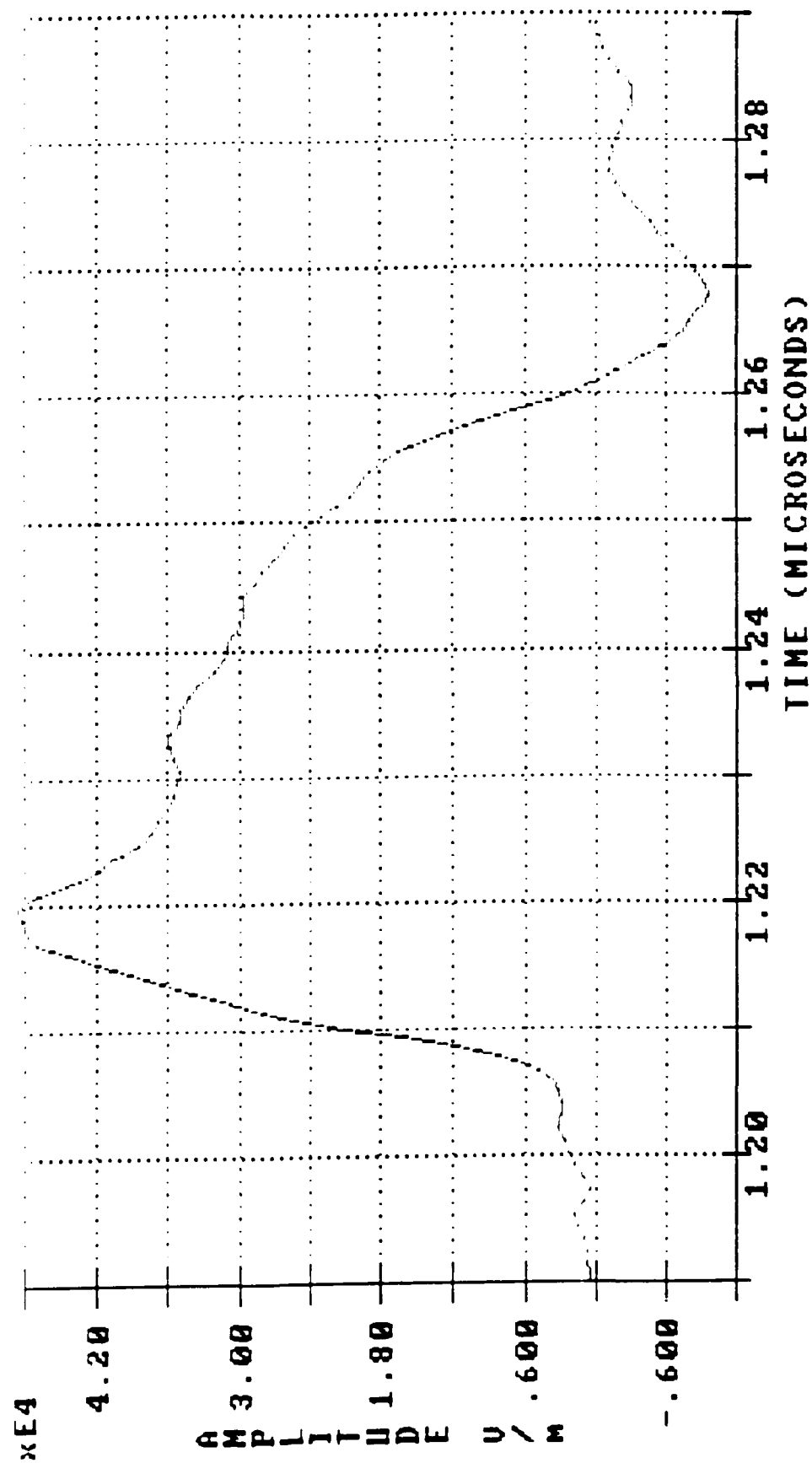
SHOT #: 14850 D-DOT PROBE 30 AUG 1990

E-5

xE4

4.00

3.00

2.00

1.00

.000

A
M
P
L
I
T
U
D
E

V
/
M

1.69   1.71   1.73   1.75   1.77

TIME (MICROSECONDS)

SHOT #: 14850 NRL PROBE   30 AUG 1990

E-6

SHOT #: 14850 NIST PROBE 30 AUG 1990

E-7

SHOT #: 14857 D-DOT PROBE 30 AUG 1990

E-8

SHOT #: 14857 NRL PROBE   30 AUG 1990

TIME (MICROSECONDS)

E-9
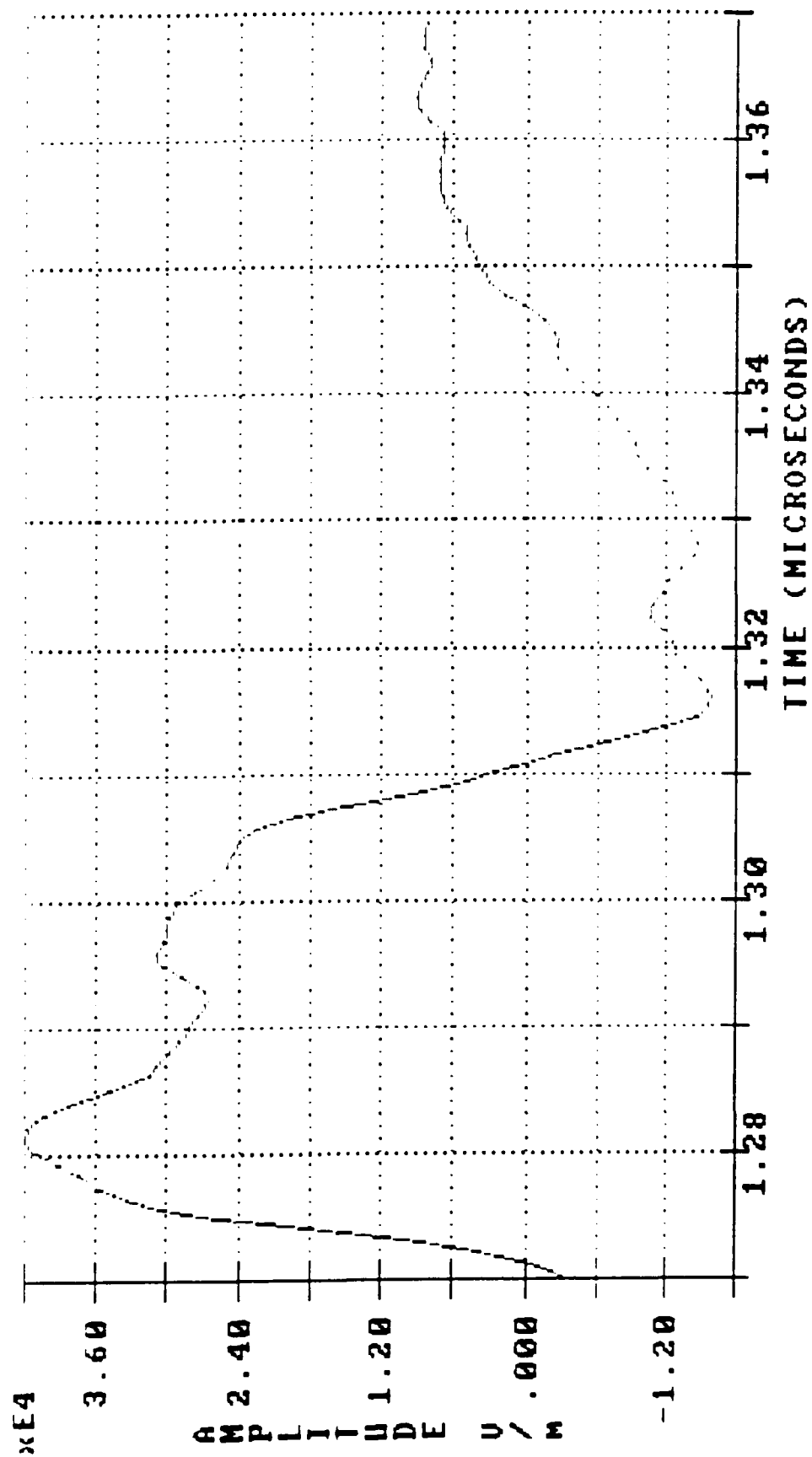
SHOT #: 14857 NIST PROBE 30 AUG 1990

E-10
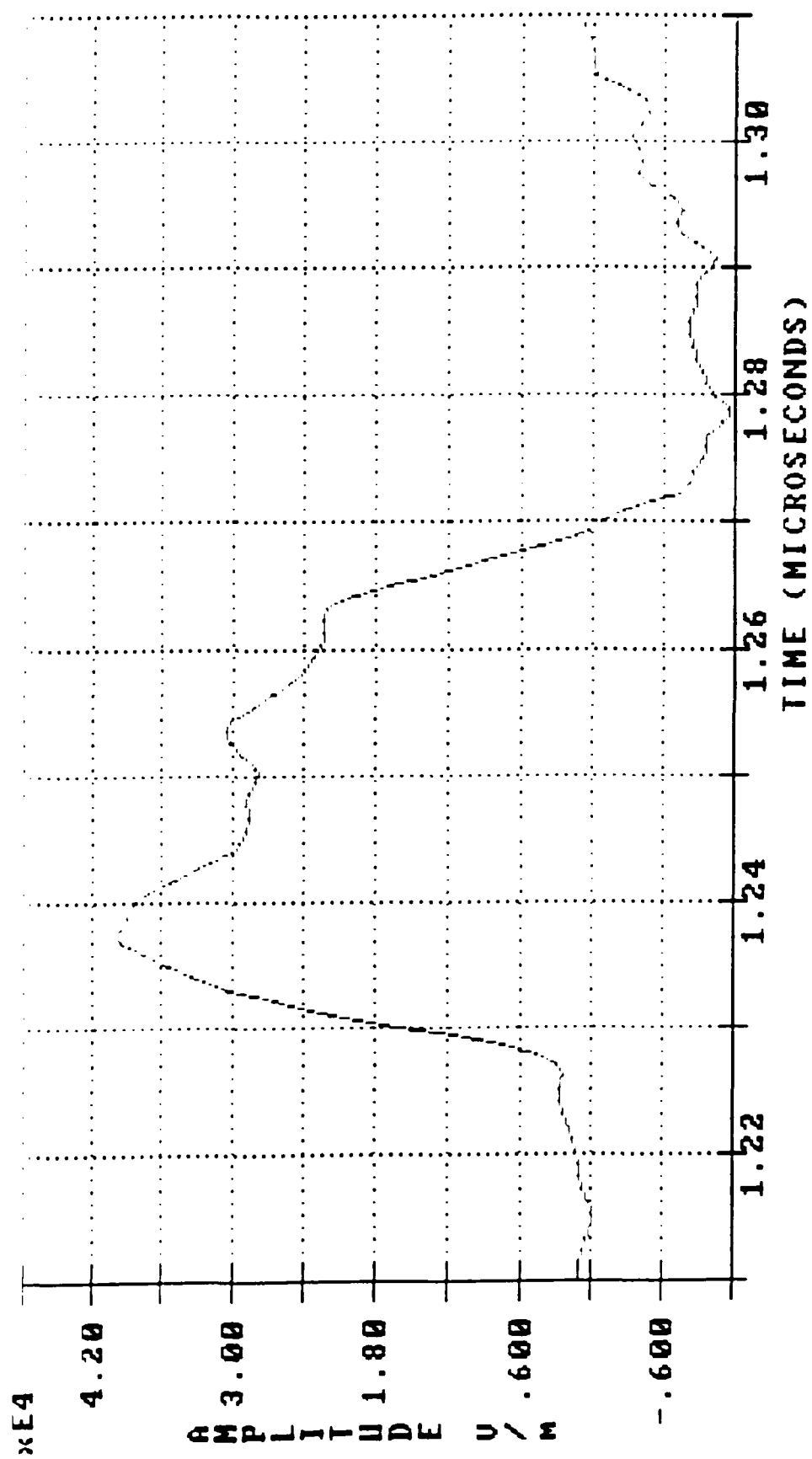
SHOT #: 14860   D-DOT PROBE   30 aug 1990

E-11

SHOT #: 14860 NRL PROBE 30 AUG 1990

E-12
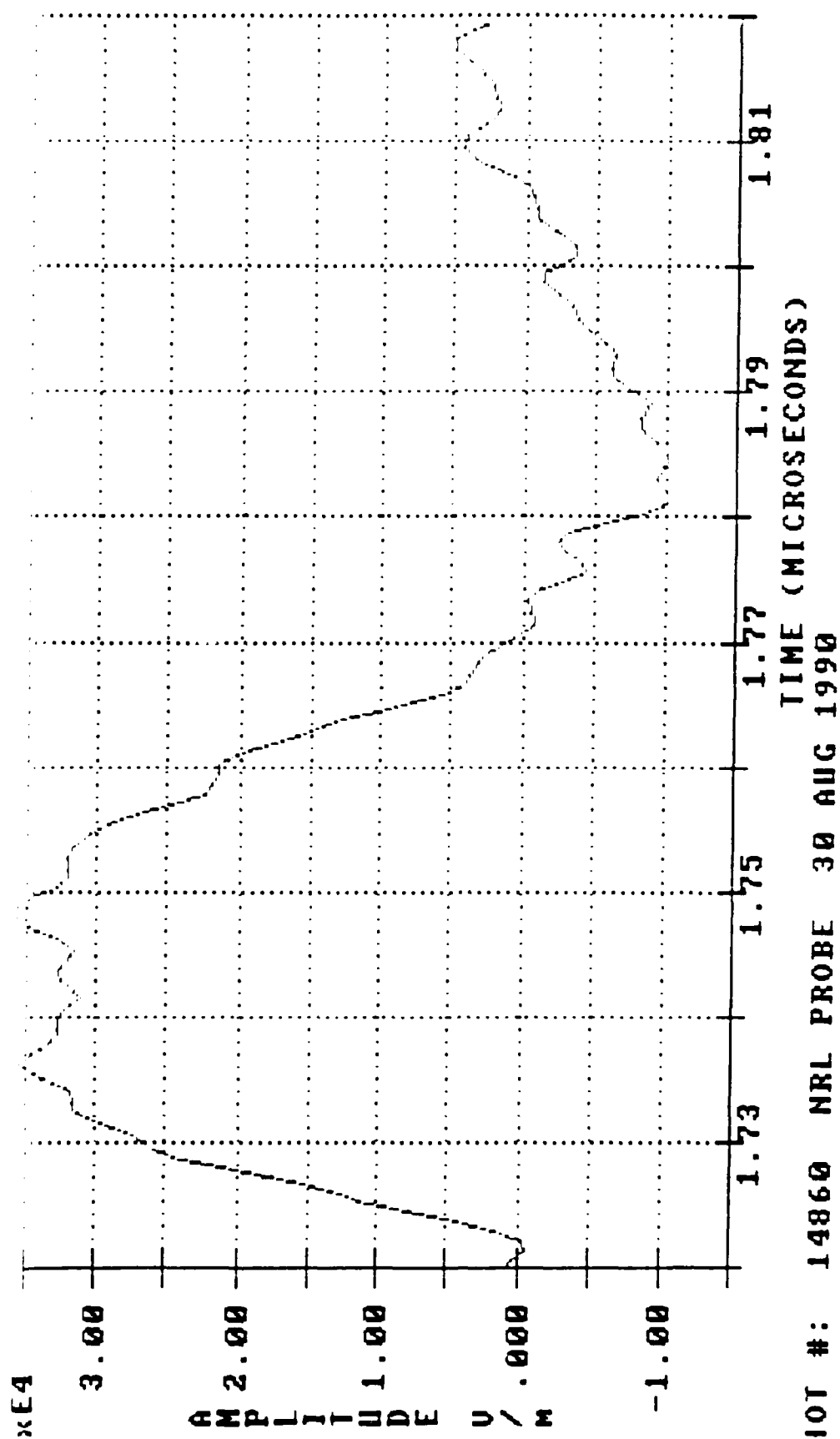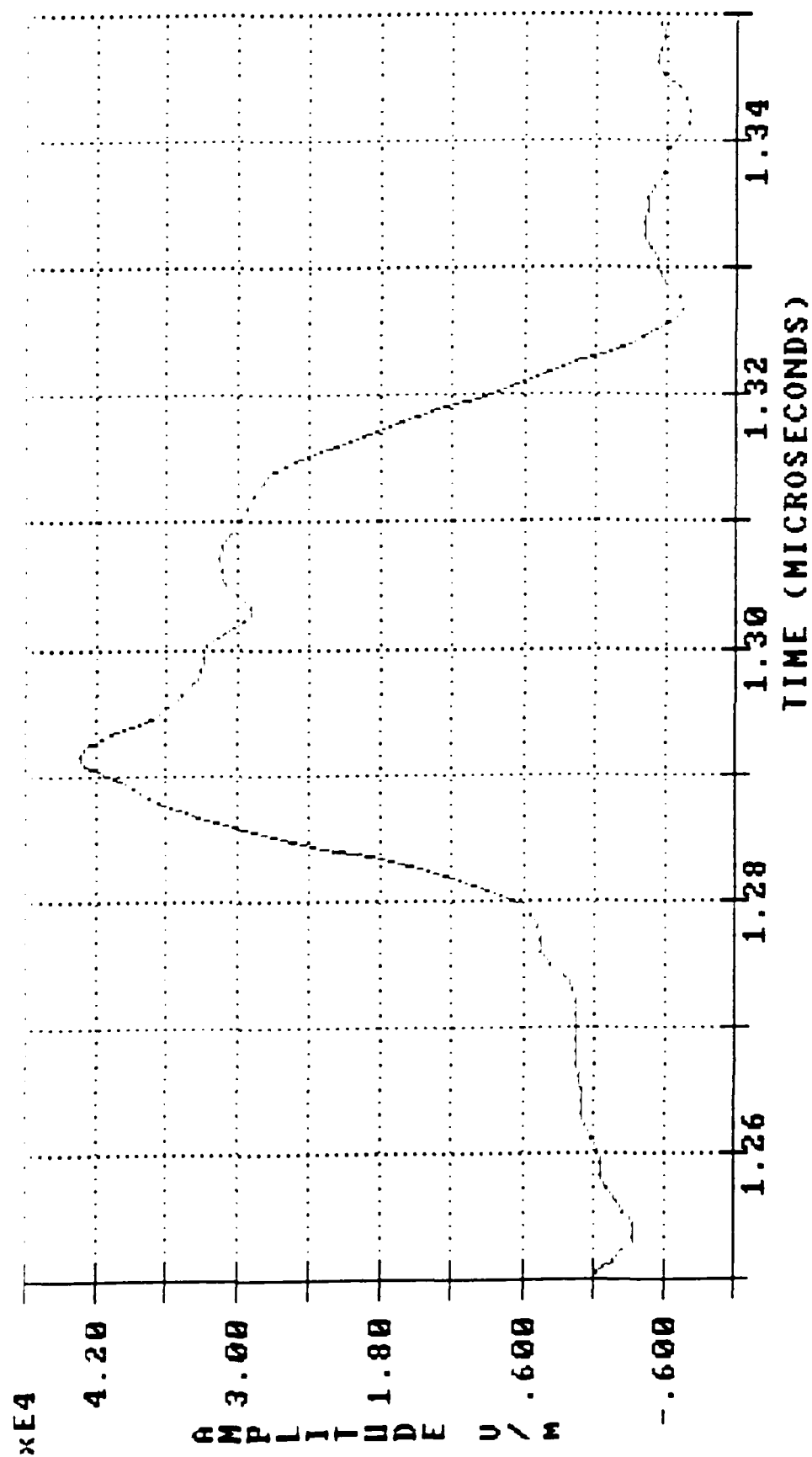
SHOT #: 14860 NIST PROBE 30 AUG 1990

E-13
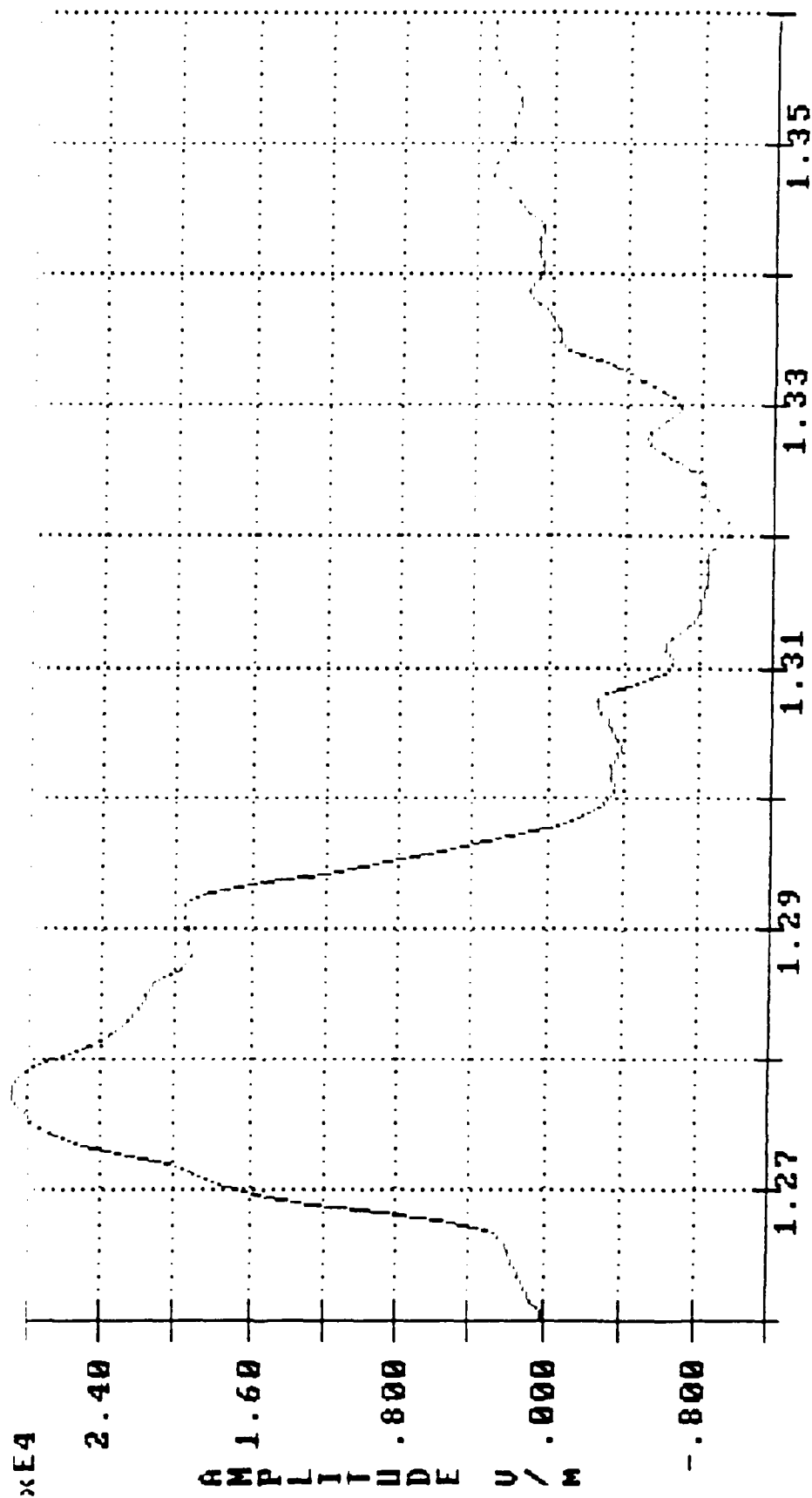
SHOT #: 14870 'd-dot PROBE 30 aug 1990

E-14

SHOT #: 14870 NRL PROBE 30 AUG 1990

E-15
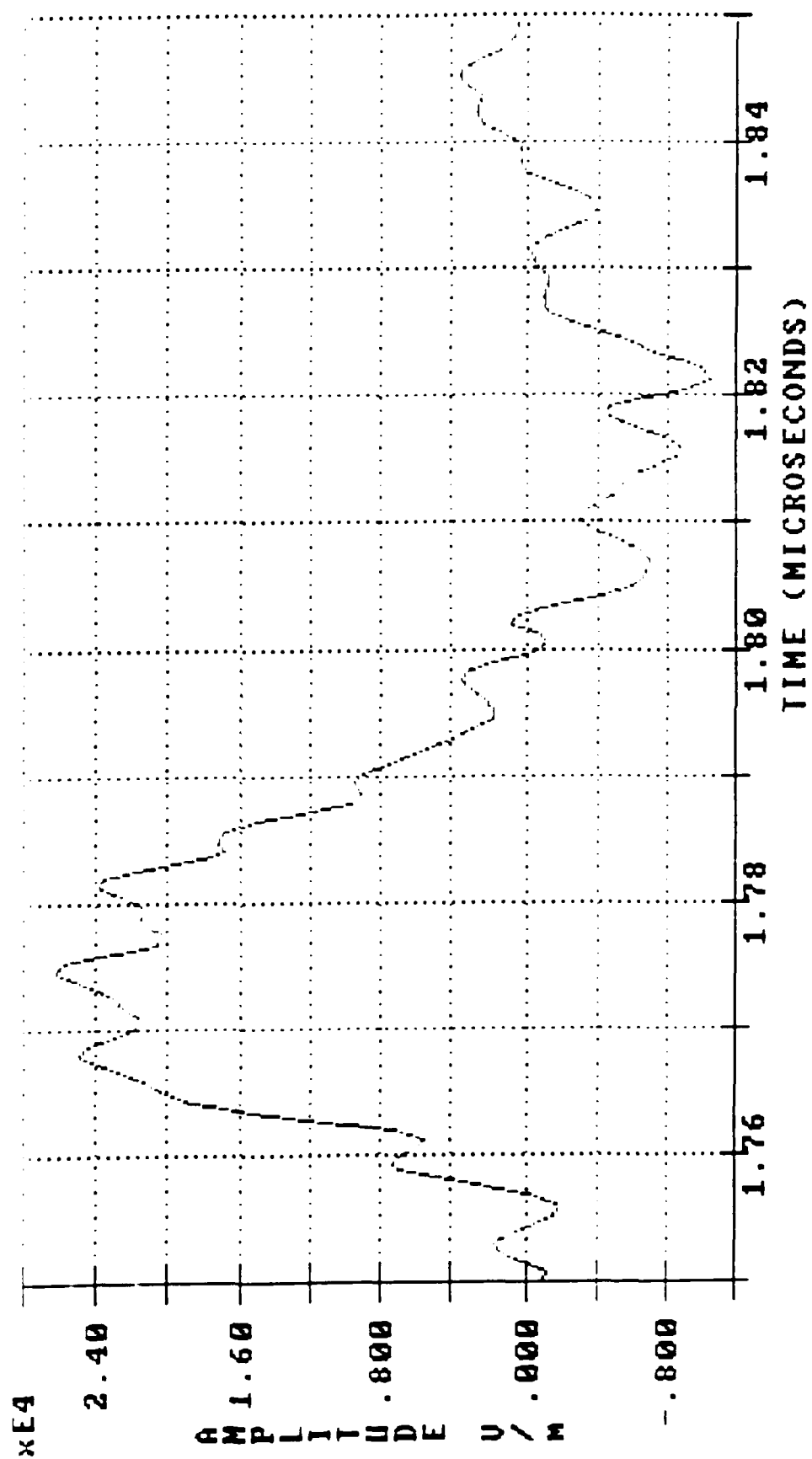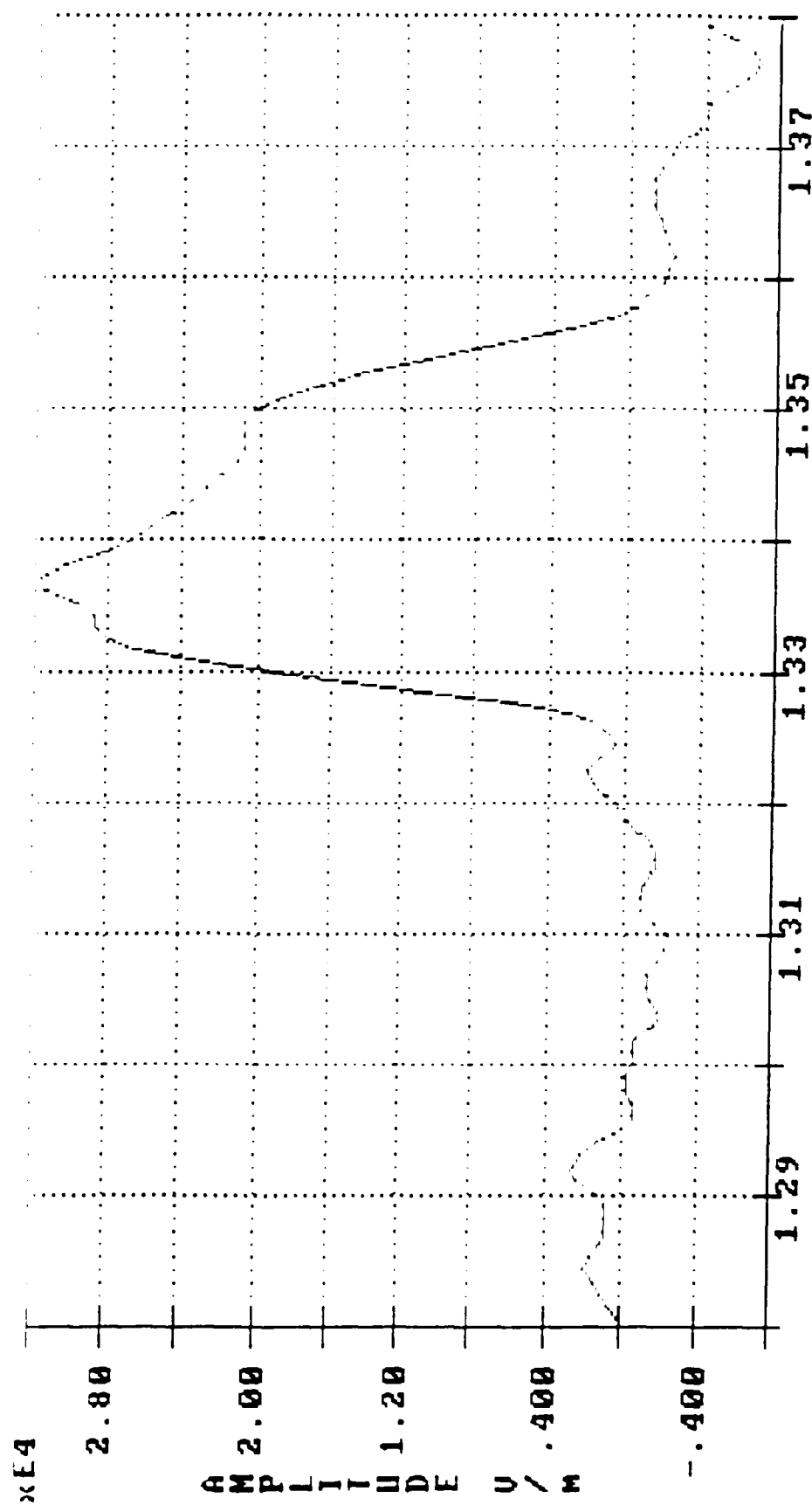
SHOT #: 14870 NIST PROBE   30 AUG 1990

SHOT #: 14873   D-DOT PROBE   30 AUG 1990

xE4

AMPLITUDE V/m

2.40

1.60

.800

.000

-.800

TIME (MICROSECONDS)

1.76   1.78   1.80   1.82   1.84
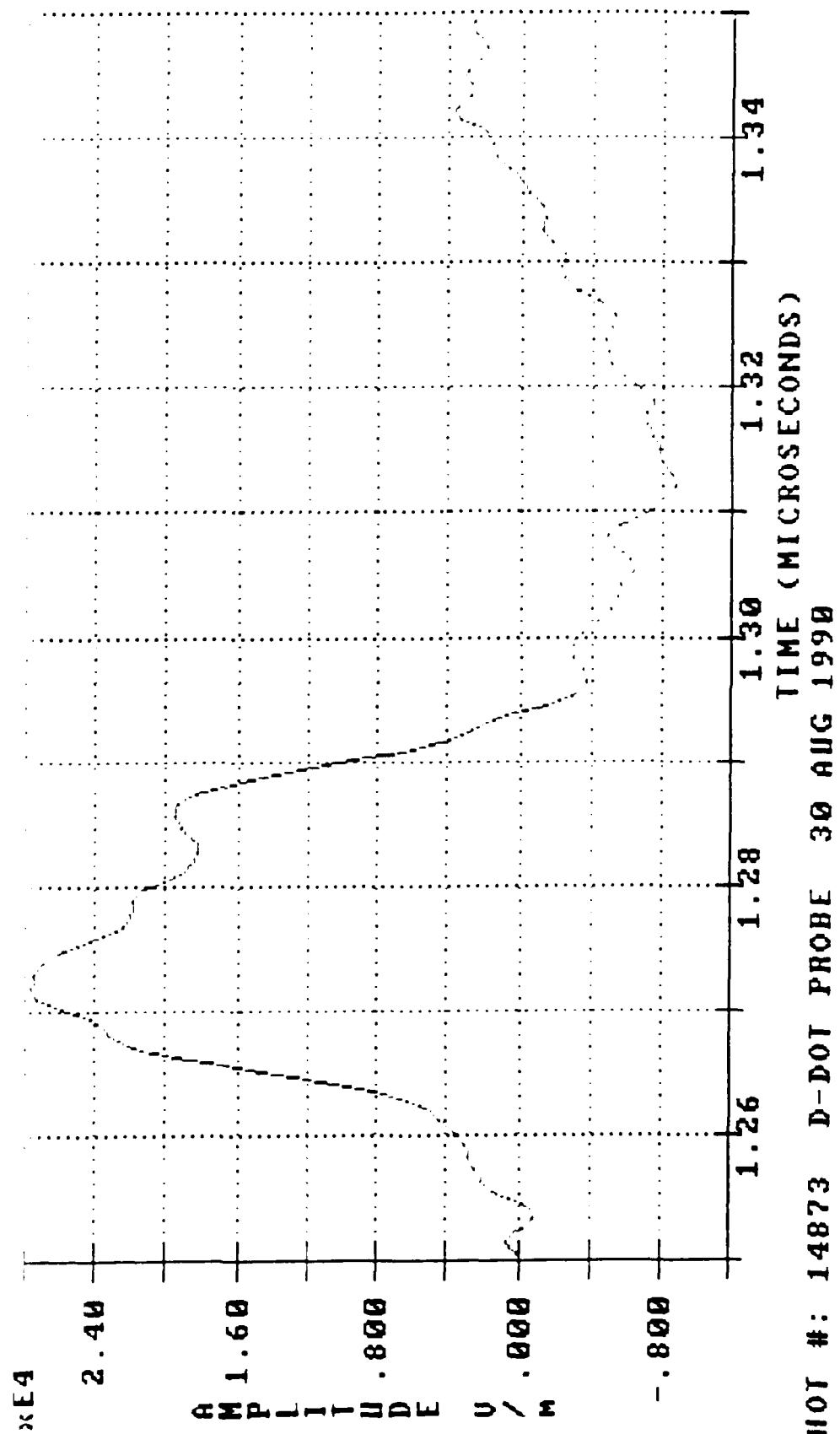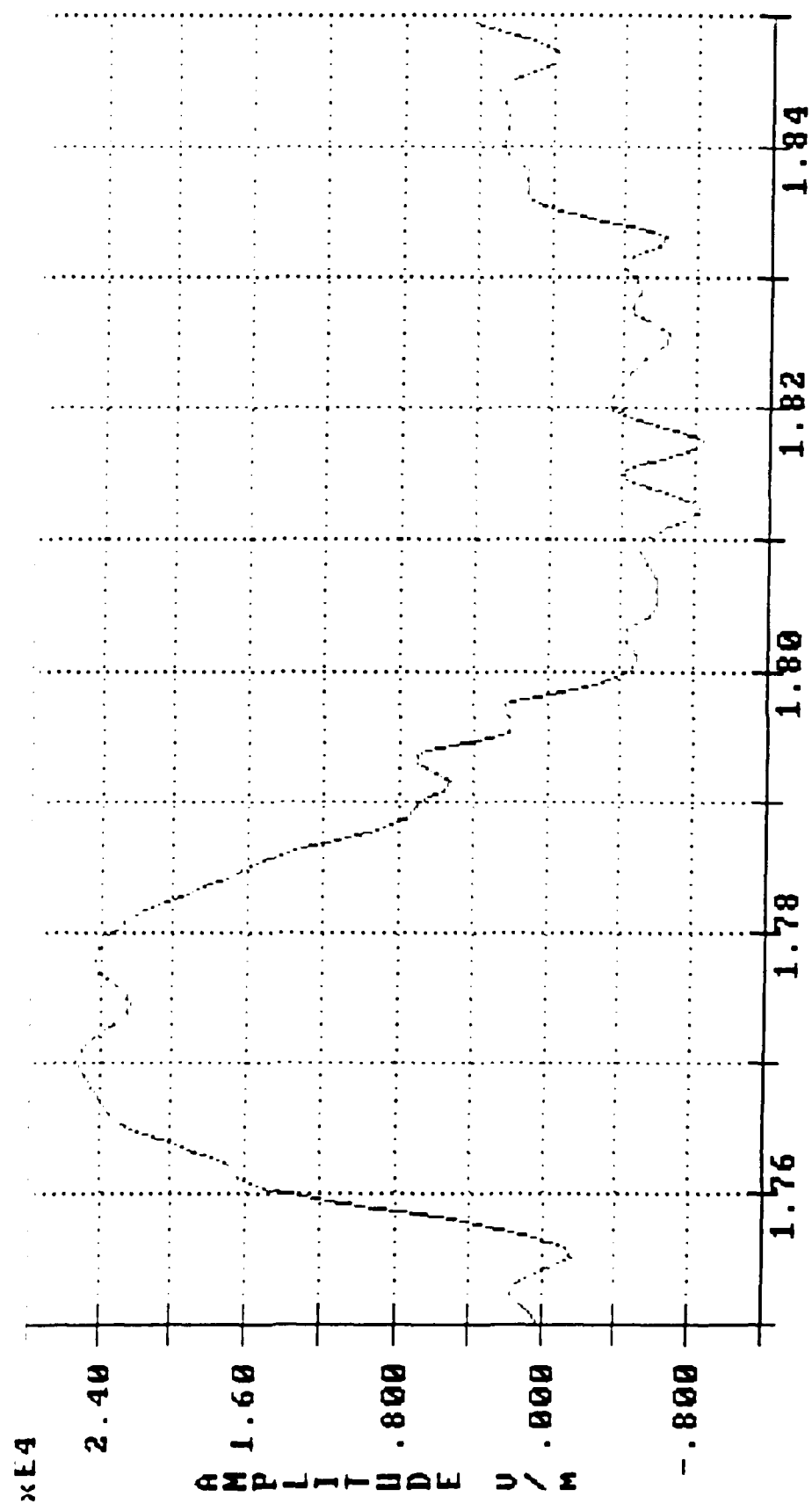
SHOT #: 14873   NRL PROBE   30 AUG 1990
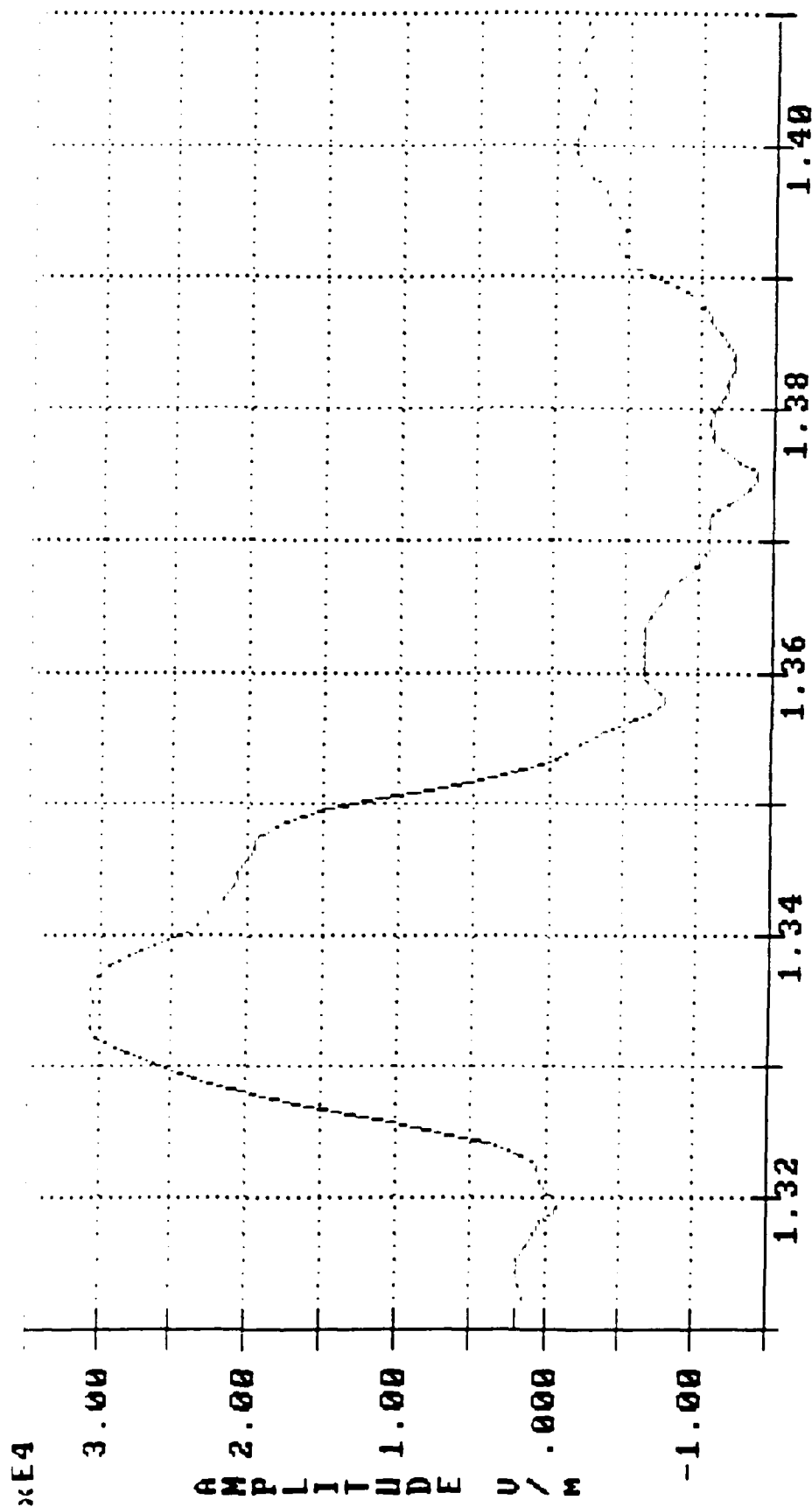
SHOT #: 14873   NIST PROBE   30 AUG 1990

APPENDIX F

LABORATORY CALIBRATED DATA

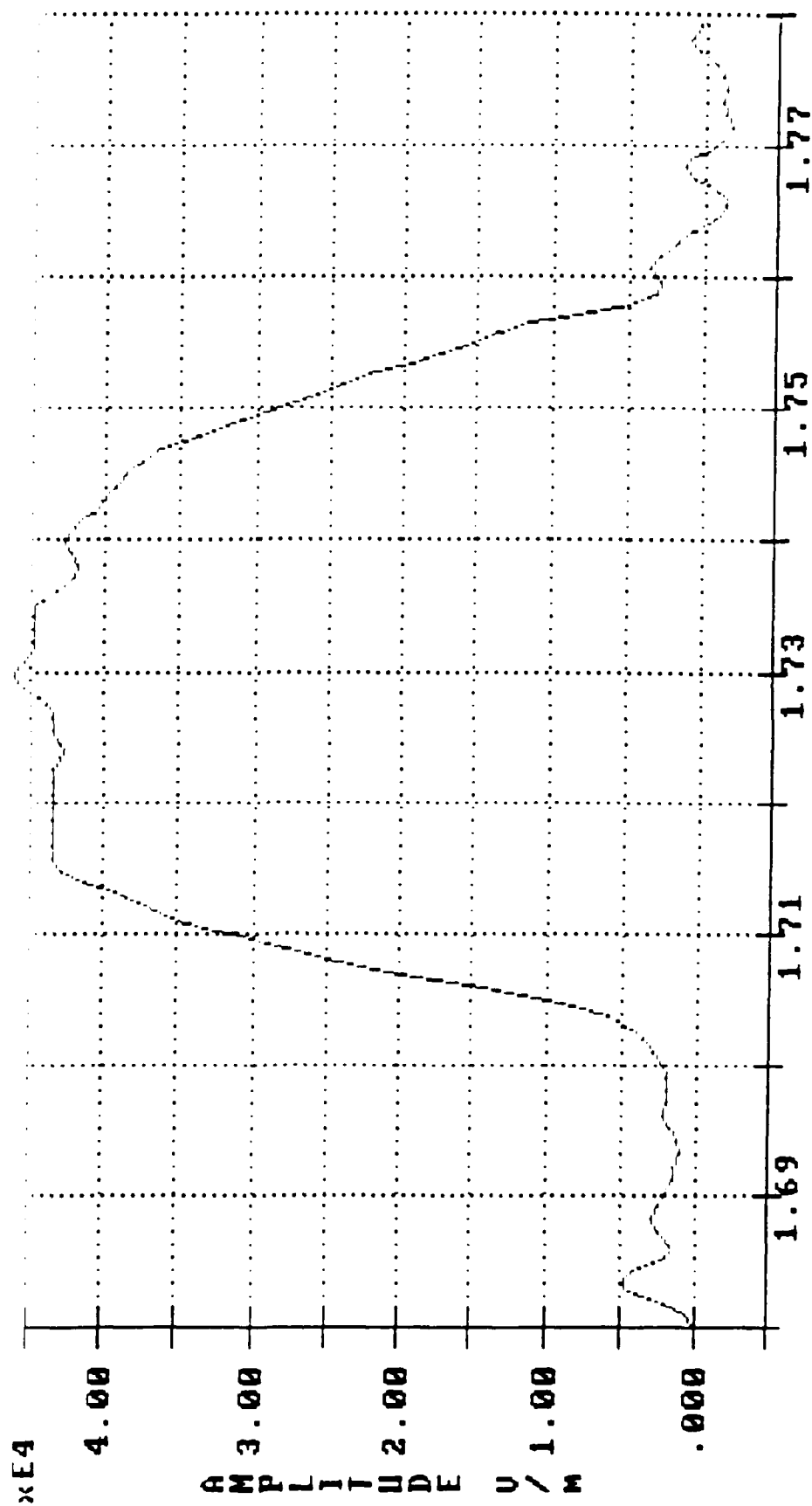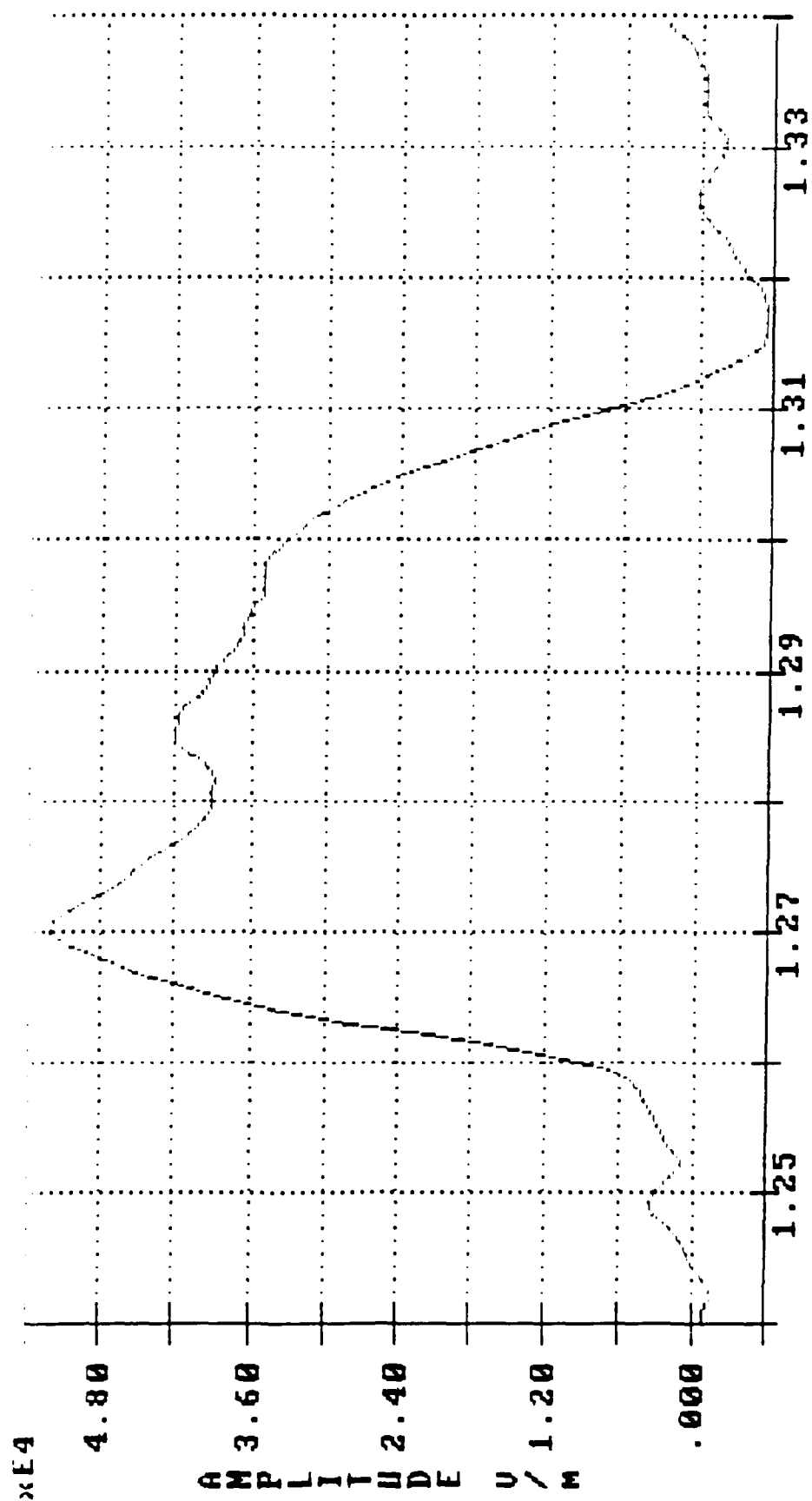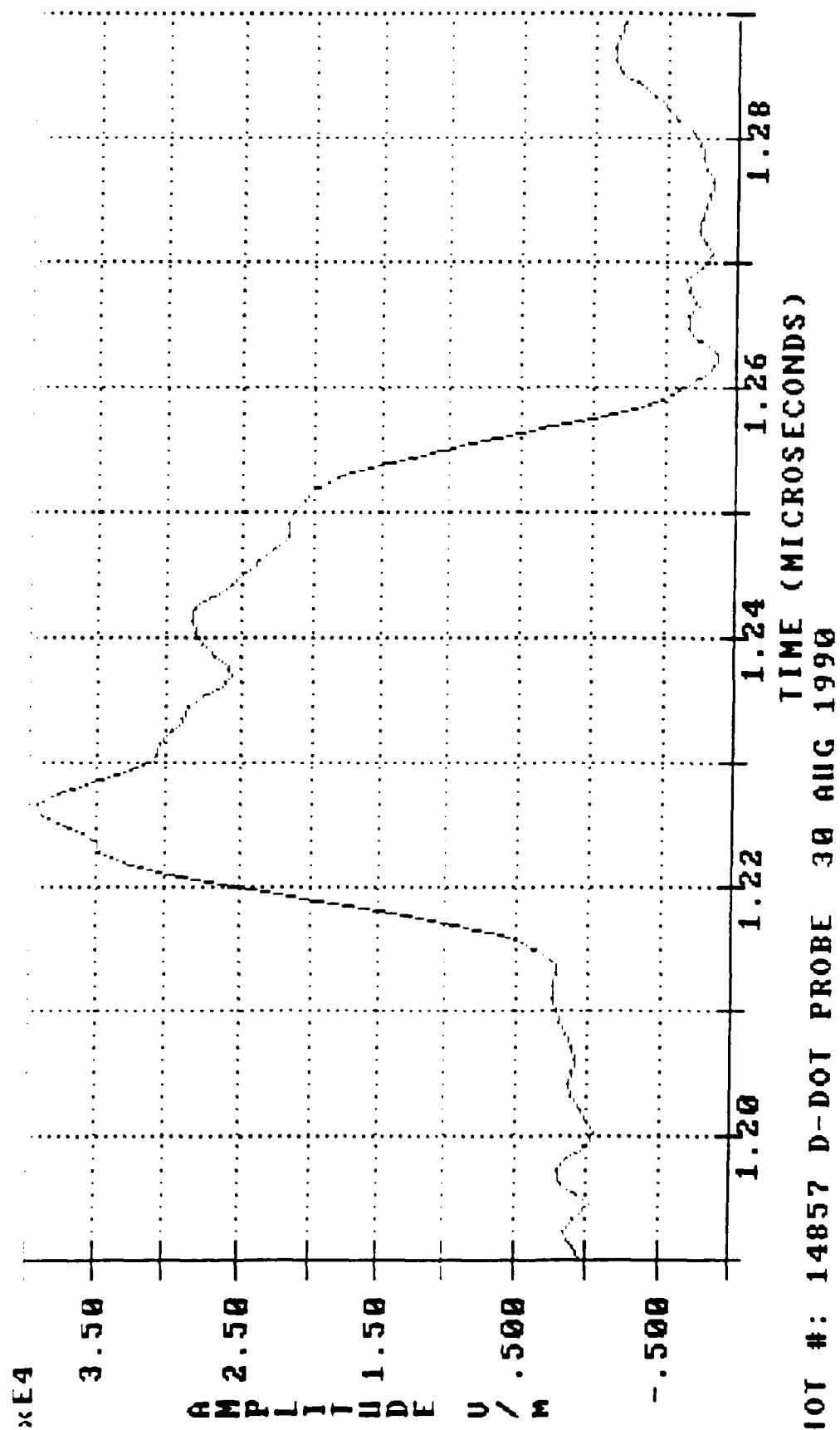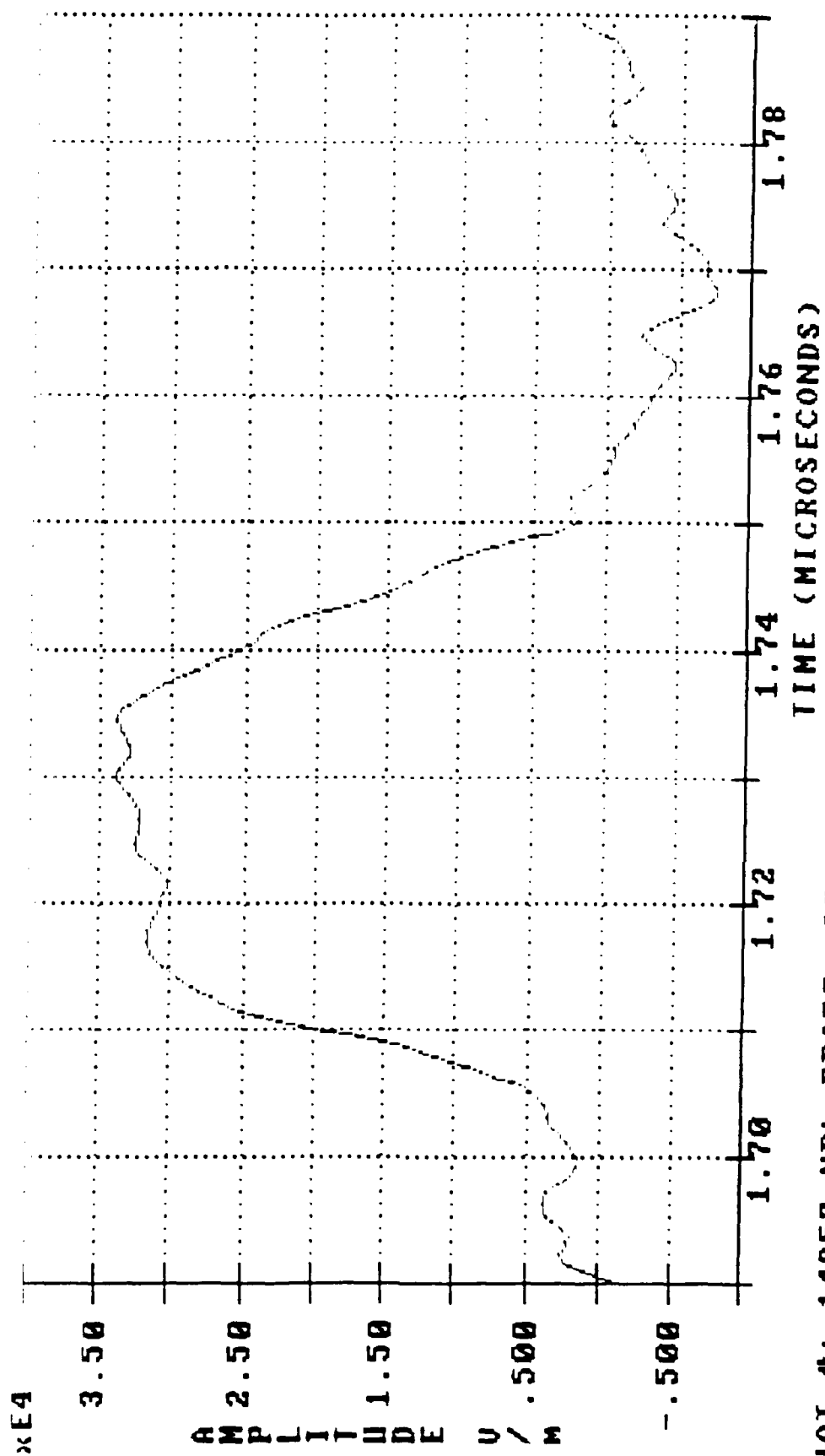The tables in this appendix show the measured E-fields recorded by DAPS for the D•Dot reference sensor. The displayed NRL and NIST values result from applying the calibration factors provided by the laboratories for their respective sensor systems. As discussed in the text, the NRL and NIST values are considerably lower than comparable reference values.

Additionally, there is an apparent discrepancy in the data displayed for the NIST sensor in that the average value for the NIST readout with the antenna in the reversed position at 9 m is higher than the average value for that sensor at that distance with the antenna in the original position. Just the opposite is true for the NIST readings taken at the 20 m position (compare NIST values on page F-2 with NIST values on page F-3).

These anomalies were solved by conducting some statistical analysis on the data. In the first instance, the low values from both the NRL and NIST sensors were compensated for by using the raw data gathered at the test site and comparing that data to the reference sensor output which were, in turn, normalized to the 50 kV/m, 40 kV/m, and 30 kV/m values at the associated distances of 9 m, 20 m, and 33 m, respectively. This statistical analysis is displayed in Appendix G. In the second instance, the apparent discrepancy in the NIST data was compensated for by averaging the antenna readouts from the NRL and the NIST sensors for a given distance from the pulser. This averaging process is displayed on page G-4 of Appendix G.

HPD PULSE RECORD

POSITION (METERS):   X_____0_____   Y_____-9_____   Z_____6.8_____

DIPOLE ALIGNMENT: D•DOT: Original____   NRL: Original____   NIST: Original____

DATE: __August 30, 1990__

SHOT NUMBER	PEAK[1] (kV/m)	RISE (nsec)	PEAK (kV/m)		
			D•DOT	NRL	NIST
14838	16.8	7.6	42.9	25.8	25.5
14841	15.7	7.8	44.8	26.7	28.6
14842	16.0	7.8	45.3	25.5	29.2
14843	15.7	7.6	45.1	24.6	28.8
14844	16.4	7.8	46.2	26.7	29.6

POSITION (METERS):   X_____0_____   Y_____-9_____   Z_____6.8_____

DIPOLE ALIGNMENT: D•DOT: Original____   NRL: Reversed____   NIST: Reversed____

DATE: __August 30, 1990__

SHOT NUMBER	PEAK[1] (kV/m)	RISE (nsec)	PEAK (kV/m)		
			D•DOT	NRL	NIST
14848	17.9	7.5	49.7	27.4	38.5
14849	16.1	7.6	45.9	25.8	36.4
14850	17.4	7.5	48.6	27.8	39.0
14851	17.4	7.5	49.1	27.4	39.6
14852	16.4	7.5	45.4	26.2	37.6

POSITION: X - PERPENDICULAR TO PAD CENTER LINE (PARALLEL TO PLANE OF THE PULSER)
X - ALONG OR PARALLEL TO PAD CENTER LINE (PERPENDICULAR TO PLANE OF THE PULSER)
Z - PERPENDICULAR TO GROUND PLANE OF PAD

NOTE 1:   PEAK ELECTRIC FIELD IS GIVEN AS GENERAL REFERENCE INFORMATION AFTER EACH HPD SHOT. THE VALUE IS CALCULATED FROM A MAGNETIC FIELD MEASUREMENT TAKEN FROM A SENSOR ON A REFERENCE BOOM LOCATED AT APPROXIMATELY 60 m ALONG THE Y AXIS

HPD PULSE RECORD

POSITION (METERS):   X_____0_____   Y_____-20_____   Z_____5.9_____

DIPOLE ALIGNMENT: D•DOT: Original_____   NRL: Reversed_____   NIST: Reversed_____

DATE: August 30, 1990

SHOT NUMBER	PEAK[1] (kV/m)	RISE (nsec)	PEAK (kV/m)		
			D•DOT	NRL	NIST
14853	16.4	7.5	36.7	20.8	23.5
14854	15.6	7.6	35.1	19.3	23.8
14855	16.1	7.6	36.9	19.4	22.9
14856	17.4	7.3	39.4	20.2	23.8
14857	17.3	7.6	40.1	19.9	26.9

POSITION (METERS):   X_____0_____   Y_____-20_____   Z_____6.8_____

DIPOLE ALIGNMENT: D•DOT: Original_____   NRL: Original_____   NIST: Original_____

DATE: August 30, 1990

SHOT NUMBER	PEAK[1] (kV/m)	RISE (nsec)	PEAK (kV/m)		
			D•DOT	NRL	NIST
14859	17.5	7.5	39.4	22.4	30.8
14860	17.7	7.5	39.9	22.4	33.1
14861	17.4	7.5	37.7	23.2	30.0
14862	17.4	7.6	39.6	21.9	30.0
14863	17.4	7.5	39.5	21.9	31.3

POSITION: X - PERPENDICULAR TO PAD CENTER LINE (PARALLEL TO PLANE OF THE PULSER)
X - ALONG OR PARALLEL TO PAD CENTER LINE (PERPENDICULAR TO PLANE OF THE PULSER)
Z - PERPENDICULAR TO GROUND PLANE OF PAD

NOTE 1:   PEAK ELECTRIC FIELD IS GIVEN AS GENERAL REFERENCE INFORMATION AFTER EACH HPD SHOT. THE VALUE IS CALCULATED FROM A MAGNETIC FIELD MEASUREMENT TAKEN FROM A SENSOR ON A REFERENCE BOOM LOCATED AT APPROXIMATELY 60 m ALONG THE Y AXIS

HPD PULSE RECORD

POSITION (METERS): X _____0_____ Y _____-33_____ Z _____5.0_____

DIPOLE ALIGNMENT: D•DOT: _Original___ NRL: _Original___ NIST: _Original___

DATE: _August 30, 1990_

SHOT NUMBER	PEAK[1] (kV/m)	RISE (nsec)	PEAK (kV/m)		
			D•DOT	NRL	NIST
14866	16.5	7.6	26.0	16.6	20.0
14867	17.3	7.5	29.4	15.8	20.3
14868	18.0	7.5	29.7	17.1	21.7
14869	18.0	7.5	29.8	16.5	21.9
14870	17.7	7.5	28.8	16.1	21.9

POSITION (METERS): X _____0_____ Y _____-33_____ Z _____5.0_____

DIPOLE ALIGNMENT: D•DOT: _Original___ NRL: _Reversed___ NIST: _Reversed___

DATE: _August 30, 1990_

SHOT NUMBER	PEAK[1] (kV/m)	RISE (nsec)	PEAK (kV/m)		
			D•DOT	NRL	NIST
14872	17.2	7.5	28.6	14.6	19.9
14873	17.2	7.6	27.5	14.0	20.1
14874	17.3	7.3	28.6	14.5	19.9
14875	18.3	7.6	30.4	14.6	21.8
14876	16.5	7.6	27.5	14.1	19.6

POSITION: X - PERPENDICULAR TO PAD CENTER LINE (PARALLEL TO PLANE OF THE PULSER)
Y - ALONG OR PARALLEL TO PAD CENTER LINE (PERPENDICULAR TO PLANE OF THE PULSER)
Z - PERPENDICULAR TO GROUND PLANE OF PAD

NOTE 1: PEAK ELECTRIC FIELD IS GIVEN AS GENERAL REFERENCE INFORMATION AFTER EACH HPD SHOT. THE VALUE IS CALCULATED FROM A MAGNETIC FIELD MEASUREMENT TAKEN FROM A SENSOR ON A REFERENCE BOOM LOCATED AT APPROXIMATELY 60 m ALONG THE Y AXIS

APPENDIX G

DATA ANALYSIS

This appendix contains a tabulation of the basic evolutions of the data for the NRL and NIST sensor systems and is discussed in Section 3.1.1 of this report.

The table on page G-2 consists of seven columns:

Column	Content Description
1	Position of sensor boom: 1st number is distance in meters from center of pad and 2nd number is altitude in meters from surface of pad; e.g., (9,6.8) refers to 9 m from center of pad and 6.8 meters in altitude above surface of the pad.
2	Shot number
3	D•Dot peak output in kV/m
4	NRL sensor system output in volts
5	Columns 5, 6 & 7 refer to the NIST sensor system: column 5 is the NIST sensor system output in volts
6	The laser optical power factor
7	The scaled output in volts is calculated by dividing the sensor system signal value by the optical power for that particular shot. For example, the top value in column 7 on G-2 is calculated in the following manner:

$$\text{Scaled Output: } 2.18 \times 10^{-1} \text{ V} = (8.96 \times 10^{-2} \text{ V})/(0.41)$$

The table on page G-3 repeats columns 1 and 2 from page G-2 for ease of reference. The normalized values of the reference sensor are displayed in column 3. Column 4 contains the normalization factor which is obtained by dividing the D•Dot N (for Normalized) value by its comparable value from column 3 in the table on page G-2. For example, in shot 14838, the normalization factor in column 4 on page G-3 is calculated by dividing the value in column 3 on G-3 by the comparable value in column 3 on page G-2: Normalization factor = (50.0 kV/m)/(42.9 kV/m) = 1.1655 = 1.17. Values in columns 5 and 6 of the table on page G-3 (NRL N and NIST N) are calculated by multiplying their comparable values from columns 4 and 7, respectively, on page G-2 by the normalization factor for that shot. Example: again, for shot 14838; NRL N value = $(1.12 \times 10^{-3} \text{ V})(1.17) = 1.31 \times 10^{-3}$ V.

The table on page G-4 compensates for the differences in the test sensor outputs (as discussed in Section 3.0 and displayed in Appendix F) due to the two orientations of the test sensor antennas. The values in columns 3 and 4 on page G-4 are obtained by averaging the values from a pair of shot numbers with opposite antenna orientations and multiplying that result by the test sensor conversion factor obtained from Figure 3-1 or Figure 3-2 as the case may be. For example; shots 14838 and 14848 have opposite antenna configurations for the same sensor position; hence, the **NRL** value at the top of column 3 on page G-4 is calculated as follows:

NRL value (kV/m) = (Average of values from page G-3)(NRL conversion factor)

  = $[(1/2)(1.31 + 1.20) \times 10^{-3} \text{ V}](3.72 \times 10^7 \text{ /m}) = 46.7 \text{ kV/m}$

POSITION m	SHOT	D•DOT kV/m	NRL 10^{-2} V	NIST		
				SIGNAL 10^{-2} V	OPT POWER FACTOR	SCALED 10^{-1} V
9,6.8	14838	42.9	1.12	8.96	0.41	2.18
9,6.8	14841	44.8	1.16	10.7	0.42	2.54
9,6.8	14842	45.3	1.11	10.9	0.42	2.60
9,6.8	14843	45.1	1.07	9.73	0.38	2.56
9,6.8	14844	46.2	1.16	10.5	0.40	2.63
9,6.8	14848	49.7	1.19	14.8	0.43	3.43
9,6.8	14849	45.9	1.12	12.3	0.38	3.24
9,6.8	14850	48.6	1.21	12.5	0.36	3.47
9,6.8	14851	49.1	1.19	14.1	0.40	3.49
9,6.8	14852	45.4	1.14	14.4	0.43	3.35
20,5.9	14853	36.7	.907	8.16	0.39	2.09
20,5.9	14854	35.1	.837	8.06	0.38	2.12
20,5.9	14855	36.9	.845	7.96	0.39	2.04
20,5.9	14856	39.4	.880	8.70	0.41	2.13
20,5.9	14857	40.1	.863	8.85	0.37	2.39
20,5.9	14859	39.4	.973	10.4	0.38	2.74
20,5.9	14860	39.9	.972	10.9	0.37	2.95
20,5.9	14861	37.7	1.01	10.4	0.39	2.67
20,5.9	14862	39.6	.951	10.4	0.39	2.67
20,5.9	14863	39.5	.950	10.6	0.38	2.79
33,5.0	14866	26.0	.720	6.40	0.36	1.78
33,5.0	14867	29.4	.687	5.80	0.32	1.81
33,5.0	14868	29.7	.743	6.00	0.31	1.94
33,5.0	14869	29.8	.719	7.00	0.36	1.94
33,5.0	14870	28.8	.707	7.00	0.36	1.94
33,5.0	14872	28.6	.643	6.20	0.35	1.77
33,5.0	14873	27.5	.606	5.90	0.33	1.79
33,5.0	14874	28.6	.630	6.90	0.39	1.77
33,5.0	14875	30.4	.633	6.80	0.35	1.94
33,5.0	14876	27.5	.615	6.80	0.39	1.74

POSITION m	SHOT	D DOT N kV/m	NORM FACT	NRL N 10^{-2} V	NIST N 10^{-1} V
9,6.8	14838	50.0	1.17	1.31	2.54
9,6.8	14841	50.0	1.12	1.29	2.84
9,6.8	14842	50.0	1.10	1.23	2.86
9,6.8	14843	50.0	1.11	1.19	2.84
9,6.8	14844	50.0	1.08	1.26	2.84
9,6.8	14848	50.0	1.01	1.20	3.45
9,6.8	14849	50.0	1.09	1.22	3.53
9,6.8	14850	50.0	1.03	1.24	3.57
9,6.8	14851	50.0	1.02	1.21	3.55
9,6.8	14852	50.0	1.10	1.26	3.69
20,5.9	14853	40.0	1.09	.989	2.28
20,5.9	14854	40.0	1.14	.954	2.42
20,5.9	14855	40.0	1.08	.916	2.21
20,5.9	14856	40.0	1.02	.893	2.16
20,5.9	14857	40.0	1.00	.861	2.39
20,5.9	14859	40.0	1.02	.988	2.78
20,5.9	14860	40.0	1.00	.974	2.95
20,5.9	14861	40.0	1.06	1.07	2.83
20,5.9	14862	40.0	1.01	.961	2.69
20,5.9	14863	40.0	1.01	.962	2.82
33,5.0	14866	30.0	1.15	.831	2.05
33,5.0	14867	30.0	1.02	.701	1.85
33,5.0	14868	30.0	1.01	.751	1.96
33,5.0	14869	30.0	1.01	.724	1.96
33,5.0	14870	30.0	1.04	.736	2.03
33,5.0	14872	30.0	1.05	.674	1.86
33,5.0	14873	30.0	1.09	.661	1.95
33,5.0	14874	30.0	1.05	.661	1.86
33,5.0	14875	30.0	0.99	.625	1.92
33,5.0	14876	30.0	1.09	.671	1.90

POSITION	SHOT	NRL kV/m	NIST kV/m
9,6.8	14838 / 14848	46.7	48.5
9,6.8	14841 / 14849	46.7	51.6
9,6.8	14842 / 14850	45.9	52.1
9,6.8	14843 / 14851	44.6	51.8
9,6.8	14844 / 14852	46.9	52.9
20,5.9	14853 / 14859	36.8	41.0
20,5.9	14854 / 14860	35.9	43.5
20,5.9	14855 / 14861	36.9	40.8
20,5.9	14856 / 14862	34.5	39.3
20,5.9	14857 / 14863	33.9	42.2
33,5.0	14866 / 14872	28.0	33.0
33,5.0	14867 / 14873	25.3	30.8
33,5.0	14868 / 14874	26.3	30.9
33,5.0	14869 / 14875	25.1	31.4
33,5.0	14870 / 14876	26.2	31.8

APPENDIX H

PHOTONIC ELECTRIC-FIELD PROBE
TEST PLAN
7 July 1989

BACKGROUND

1. Under Naval Research Laboratory (NRL) Contract N00014-C-90-2033, ARC Professional Services Group (ARC) is tasked to support the Naval Air Systems Command, Code AIR-5161, to identify and evaluate dielectric sensors which measure the electric field intensity at the TACAMO Electromagnetic Pulse Simulator (TES), at Naval Air Test Center (NATC), Patuxent River, Maryland. To accomplish this task, ARC and NRL have identified two (possibly three) sensors as potential candidates for testing at the TES site.

2. This test plan outlines the test method to be used to gather data required for the evaluations. The tests will be conducted concurrently with scheduled tests conducted for the U.S. Army's Harry Diamond Laboratories at the the NATC TES during the period 24 August - 6 September 1990.

PURPOSE

3. The purpose of this test is to gather data from dielectric sensors for evaluation of their suitability to measure the electric field intensity of the simulated EMP pulse at TES. The test method will be to individually install each of the sensors on the TES pad adjacent to a TES provided D-dot probe, simultaneously collect electric field strength data with each instrument and the D-dot probe simultaneously, and compare the data collected by the sensors to the respective D-dot probe data. If a D-Dot probe is not available, the positioning of the sensors under test will include locations on the test pad for which field map data is known. A readout of the E-field strengths at these points is attached to this test plan.

DESCRIPTION OF THE PROBES

4. The electric field sensors to be tested utilize respective interface units that measure 4-6 inches high and fit into a standard 19 inch rack. Optical and coaxial connectors are in front of the units.

Three channels are desired for the tests; one each for the sensors under test and one for the TES D-dot probe. Two channels would allow simultaneous data collection from one test sensor and a D-Dot probe and would provide adequate information. If limited to only one channel, testing can proceed but analysis will be severely impaired by the absence of D-dot probe data for comparison. TES will provide data collection instrumentation, including LeCroy 6880 digitizers and required cables, for the tests.

Sensors that may be tested include:

(1) A photonic E-Field sensor developed by the Sensors Division of the National Institute of Standards and Technology (NIST), Boulder, CO, for the U.S. Army's Harry Diamond Laboratories (HDL).

(2) A photonic E-Field sensor developed by NRL.

The NIST photonic sensor, PEFM-15C, utilizes a Bismuth Germanate ($Bi_4Ge_3O_{12}$) crystal and a 15 cm cylindrical dipole mounted on a 6 cm cylindrical dipole stub. The basic operating principle of the sensor is the Linear Kerr Effect. Polarized light is directed through the $Bi_4Ge_3O_{12}$ crystal through polarization maintaining fiber and associated optics. When the sensor is subjected to an electric field, the polarization of the light through the crystal is altered in a measurable amount related to the strength of the electric field. In laboratory tests, the sensor has demonstrated frequency response to above 2 GHz, and linearity for both the 15 cm and 6 cm dipoles is calculated to be well above the 50 kV/m field strength of the TES site.

Figure 1 is a block diagram of the probe, which consists of a laser, detector, dipole antenna and a modulator. The modulator, shown in Figure 2, uses a Bismuth Germanate ($Bi_4Ge_3O_{12}$) crystal oriented so that optical propagation is along the crystal Z axis. The design of the modulator exploits the properties of the crystal in this orientation to obtain the desired thermal stability. Reflecting the optical carrier back through the crystal doubles the sensitivity of the modulator for frequencies up to a few GHz.
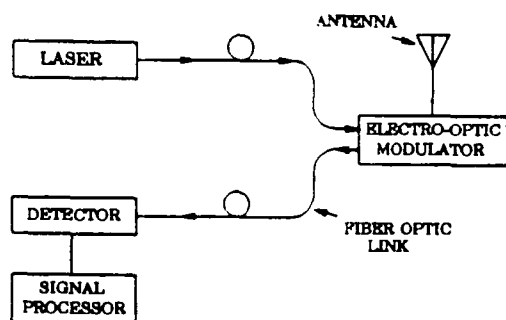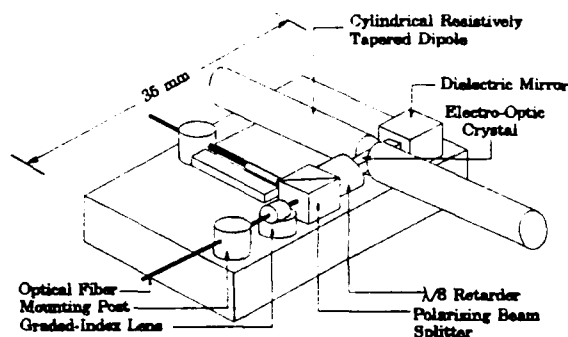

Figure 1

Figure 2

Figure 3 depicts the interface connections of the sensor to the digitizer to be used on the test site.

DESCRIPTION OF THE TEST FACILITIES

5. The test will be conducted at the TES, a horizontally polarized dipole simulation facility, at NATC. The TES pulser has a peak output voltage of 5 MegaVolts (MV), though its normal operating charge is 4 MV. At 3 meters above the ground and directly beneath the pulser, the antenna radiates an electric field close to 50 kiloVolts/meter (kV/m) with a 7 to 8 nanoseconds risetime. The TES waveform approximates the unclassified High-Altitude Electromagnetic Pulse (HEMP). The pulser is contained in a low pressure, gas tight, fiberglass enclosure, approximately 5 meters long and 3 meters in diameter. The control van contains the equipment necessary to operate and monitor the pulser. This control van also serves as the coordination point for site safety.
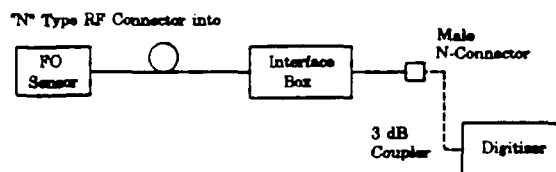

Figure 3

SCOPE OF TESTS

The test will be conducted simultaneously with the EMP testing of an E-6 aircraft using the TES facility. Current plans are to install the photonic probe and its interface box within one of the TES shielded trailers and/or on a boom to enable testing over as wide a range of field strengths as practical. Considerations for placement are the maximum fiber length inherent in the design and the dynamic range of the probe.